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ABSTRACT

Designed as an interdisciplinary, supplemental teaching guide, this document provides fundamental information about energy supply, use, and conservation and related learning activities for secondary students. Eight units address the following topics: energy history, petroleum, natural gas, coal, electricity, alternative sources, energy conservation, and energy and economics. Each unit contains teacher background information, an activity with accompanying spirit duplicating master and suggestions for additional activities. Ten exhibits (maps, charts, graphs, and illustrations) are provided on separate sheets for conversion to overhead transparencies, opague projection, or for duplication. (Author/DC)

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Energy adventure

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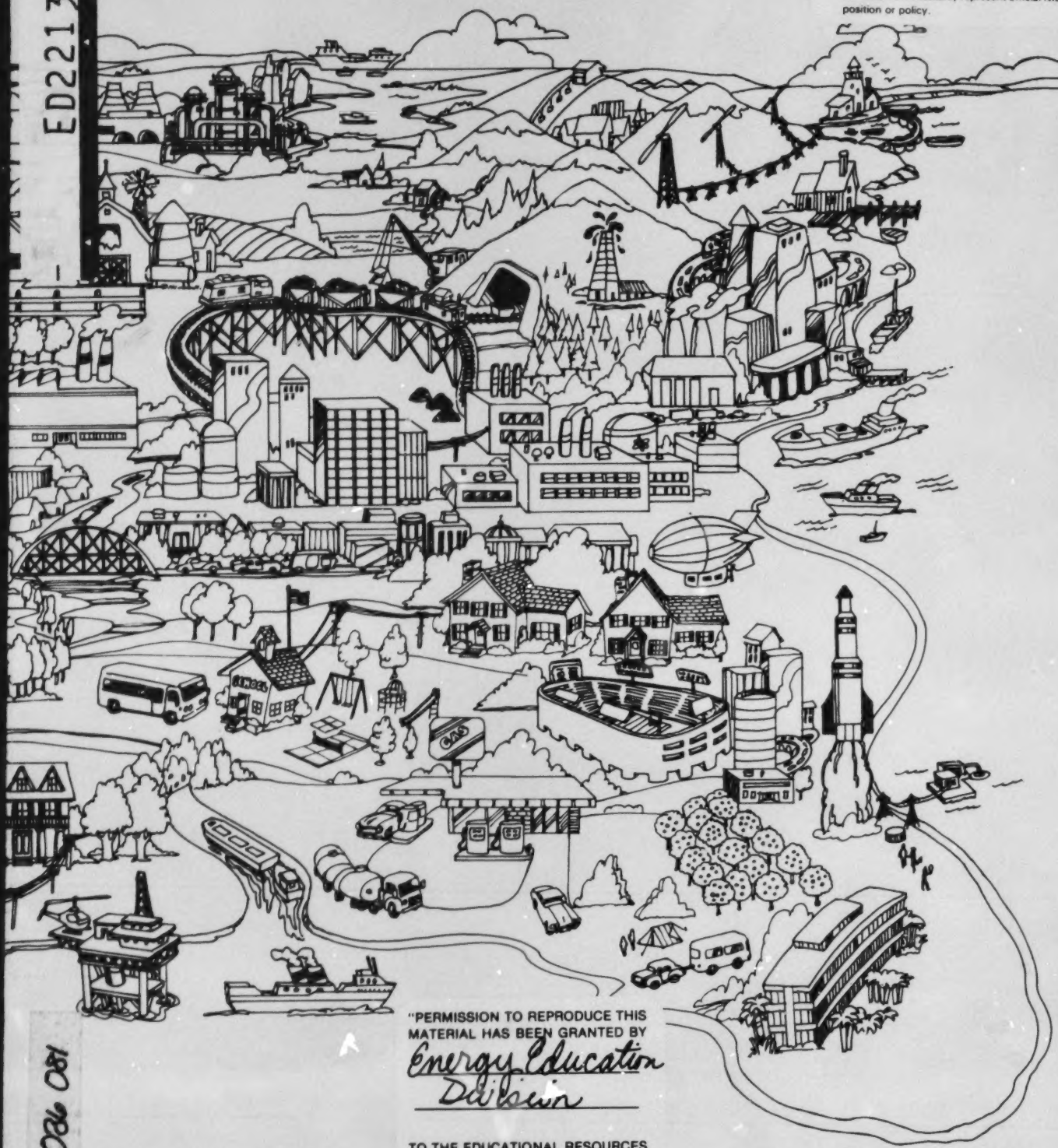

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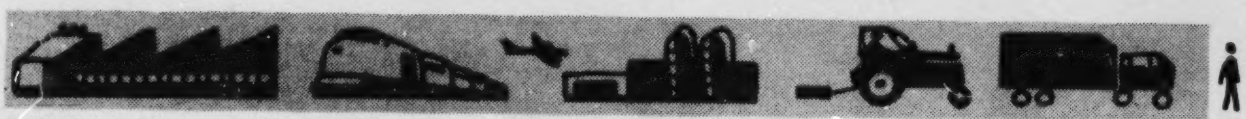
SE 026 081

Machines have taken over most of our heavy work

1850
In 1850 coal and wood powered machines that did about 35 percent of heavy work in the United States. Men and animals did the rest.

1900
Fifty years later machines were accounting for roughly 73 percent of the total.

1930
In another 30 years of industrialization, machines provided nearly 97 percent of the work output.



NOW
Today petroleum provides three-quarters of all energy used and machines do more than 99 percent of our work.

Energy adventure

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Introduction

The message of Energy Adventure is timely and positive. The United States has vast energy resources and the technological potential to build a bright future if our citizens make appropriate decisions. The activities in Energy Adventure are designed to give young adults the knowledge they will need to participate in making these decisions. Students will learn about our energy past, and options for the future.

Energy Adventure teaches fundamental concepts underlying energy conservation and use. Conservation practices, technological developments, government regulations, economic conditions, and international politics all contribute to an evolving situation. By examining our natural resources base and the current state of technology pertaining to synthetic and renewable alternative energy sources, students will gain insight into both our short-term and long-term options.

Energy Adventure is interdisciplinary. The concepts, principles, systems, and issues discussed in Energy Adventure can be infused into the regular curriculum at appropriate places. It incorporates debate, role-playing, small group brainstorming, deductive reasoning, and teacher-led discussions.

American history teachers can show how energy supply and demand affected the industrialization and urbanization of America. Science studies can deal with the chemistry and physics of burning fossil fuels or the physics of nuclear fission and fusion used to generate electricity. Geography teachers can explore the distribution and production of fossil fuels, uranium, and water resources. Home economics provides an opportunity to review the effects of energy on food production and the choices of clothing and housing. Vocational and technical studies can help prepare students for new career opportunities in energy and related industries. Social studies teachers will see students employ the tools of their discipline to complete the activities of this program.

The Energy Adventure teaching resource contains useful background information and optional suggestions to share with your class. The presentation should stimulate students to write for additional information, consult newspapers and magazines for current information, and to use the library effectively.

Each activity unit in the teacher's guide corresponds to an activity in the form of a spirit duplicating master which appears at the back of the book. These activity sheets provide a self-contained unit which can be presented sequentially, or may be used to supplement parts of your curriculum. It is a flexible program, adaptable to your teaching methods.

Each activity master will produce at least 200 copies. To make copies, remove the tissue backing, attach the master face down to the drum of your spirit duplicator, and run the copies desired. The masters can be refiled between the tissues and stored for later use. The answers printed in red on the front of the masters will not reproduce.

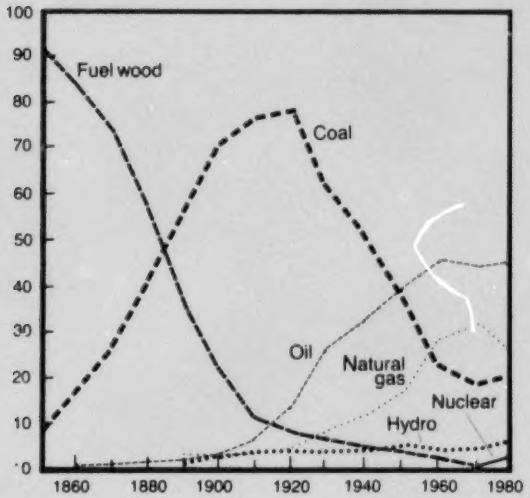
Ten exhibits are included in the form of maps, charts, graphs, and illustrations suitable for conversion to overhead transparencies, opaque projection, or for offset or copier duplication, for distribution to the class.

All references to energy sources and uses refer to the United States unless otherwise indicated.

ACTIVITY 1

Energy — The Great Adventure

U.S. Energy Sources, 1850-1980 (Percent)



STUDENT OBJECTIVES

This activity introduces the energy studies that follow. Students will better understand the contributions of wood, coal, and petroleum in relation to the historical uses of energy and the progress of the Industrial Revolution. The review of energy history can be related to today's problems and opportunities. The mini-quiz activity master should help evaluate student knowledge of the current energy situation and provide a basis for additional assignments and study in the activities that follow.

BACKGROUND AND TEACHING SUGGESTIONS

Since earliest time, people have been engaged in a great energy adventure which rapidly accelerated during the last 150 years and resulted in increasing comfort and improving standards of living.

The use of fire was humankind's first controlled use of energy. Burning wood provided warmth, light, and a means of cooking food. During most of recorded history, wood, plant fibers, and animal fats were basic fuels.

Plants, animals, people, other living organisms, and machines can change energy from one form to another. But only people have had the unique ability to harness energy resources and use them to perform work.

Energy Concepts. Energy is the ability to do work. Work is the action of a force moving an object. Power is the rate at which work is done. Different forms of energy are able to do different amounts of work. There are two major forms of energy — potential and kinetic.

Potential energy is the energy that an object or matter possesses because of its position or arrangement of parts. All matter contains potential energy. There are four types: gravitational, electrical, nuclear, and chemical.

Rivers and tides are two natural potential energy resources that can be harnessed to use the gravitational energy stored in water behind dams. When released, the potential energy in the water can be converted to kinetic energy that powers hydroelectric generators. Uranium in a reactor has potential nuclear energy which can be controlled to release heat, which in turn makes the steam to drive a turbine electric generator. Before potential energy can do work it must be changed to kinetic energy.

Kinetic energy is the energy of an object at work or in motion. Three major forms are mechanical, sound, and radiant. Mechanical energy is represented by machines in motion. Sound energy results from a series of sonic waves transmitted to the ear through air or other material. Vibrating objects such as a tuning fork or vocal cords create sound pressure waves. Radiant energy is the result of electromagnetic disturbances or waves whose energy is divided between an electric field and a magnetic field. Radiant energy can travel freely through space. Visible light is a small part of the radiant spectrum defined as the electromagnetic energy the eyes can detect. Thermal (heat) energy is the total potential and kinetic energy associated with the motion of a material's molecular particles.

Everything is either energy or matter and the two can be changed from one to the other. Energy can also be changed from one form into another, but it cannot be created or destroyed. When energy is converted, some of the original energy is changed and dissipated into other less useful forms. When we use energy we do not destroy it. We only change it into other forms. The total sum of the dissipated energy and the newly converted energy is always equal to the original energy supplied.

You may wish to duplicate Exhibit 1, Energy Conversion, and distribute it to your class. Ask students if they can think of other energy conversion devices or processes.

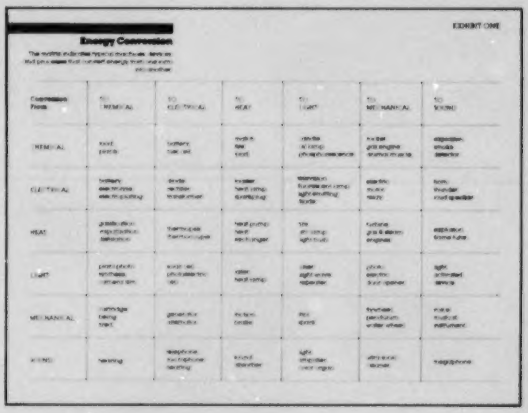


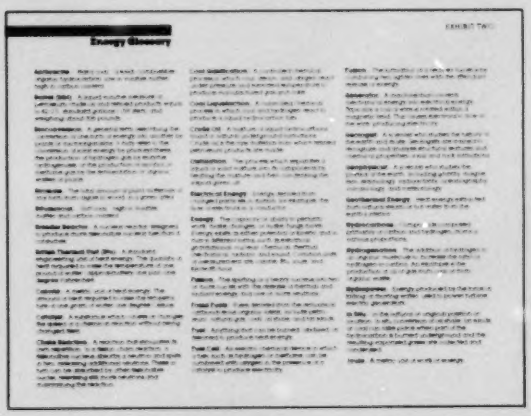
EXHIBIT ONE

Energy Conversion

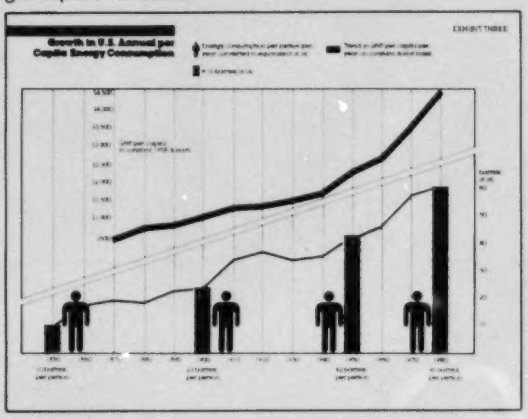
Several energy conversions take place during the operation of an automobile. Potential chemical energy is stored in gasoline. When the gasoline is pumped (mechanical) into the carburetor and then to the cylinder, it is ignited by the spark plug (heat). As the fuel burns, some of its energy is dissipated as heat. The rapidly expanding gases (kinetic energy) force the piston to move. This (mechanical) motion is transferred via a connecting rod to the crankshaft, gears, axles, and tires (friction with the road) moving the car. All of these mechanical changes result in some useful energy being dissipated in friction and heat. Only about 25 percent of the original potential energy in the gasoline is available in the final kinetic energy used to move the vehicle. The engine also mechanically drives an alternator to produce (electric) current to charge the (chemical) battery, which in turn can power (electric) headlamps (light), activate the horn (sound), operate windshield wipers (mechanical), and warm a resistance window defroster (heat).

Students can trace similar energy conversions in the production and uses of electricity.

Energy Glossary. The glossary provides students a quick reference for many of the terms discussed during the energy studies and increases their vocabulary. Reproduce the Energy Glossary, Exhibit 2, and distribute to students early in the program. Some terms that do not appear in the activities will be useful in discussion portions of the program.


Energy Glossary

Energy History. Exhibit 3 shows the dramatic Growth in U.S. Annual per Capita Energy Consumption from 1850 through 1980. Energy consumption is expressed in equivalents of barrels of oil. Annual energy consumption was about 100 million Btu per person between 1850-1900. Energy consumption doubled by 1920 and today individual energy consumption is approximately 400 million Btus per person each year. Explain to students that on the average each person in the U.S. consumed the energy *equivalent* of approximately 60 barrels of oil in 1980. Americans use 30 times the energy they used 100 years ago, but our population increased only sevenfold — which means that each student is using about four times more energy than his or her great-grandparents used.


Growth in U.S. Annual per Capita Energy Consumption

You may wish to discuss the problem of coping with exponential — geometric — growth. Offer a reward to the student who can come within one mile of guessing how thick a dollar bill would be if it were folded 50 times. (Assuming a bill is 1/100 inch in thickness, the amount would be a staggering 177,698,849 miles.) This geometric growth is reflected in population statistics. It is estimated that there were about four billion people in the world in 1975. If population growth continues as in the past, within 44 years there would be eight billion people and 16 billion inhabitants in 2063. Energy must be provided for this mass of humanity.

In the United States, early settlers depended on wood for energy because it was abundant and free. Wood continued to supply 90 percent of America's residential and industrial energy as late as the 1850s. Almost all energy was derived from renewable sources — wood, wind, and water.

People used rafts and boats to go downstream on rivers. Animals towing barges, or sailing ships moved by wind, were used for the return trip. Wind also turned windmills to pump water or grind grain, and water wheels powered a few mills and factories near streams. The U.S. was mainly an agricultural country with a population of four million people in 1790. Water power did most of the factory work. But, by the 1830s and 1840s, some factories were adapting versatile steam engines to power machines. With dependable power, plants could be built anywhere. They did not have to depend on the vagaries of the wind or the availability of moving water.

Rapid industrialization and a growing population of 23 million in 1850 created an energy demand that thinning forests could not supply. Early railroad locomotives and steamboats used wood for fuel, and it was also processed as charcoal for iron production. As wood became scarcer, it became more expensive. The country gradually turned to its abundant supply of coal. Even though it was difficult to mine, the energy concentrated in a half ton of coal would do the same work that took

ENERGY CONVERSION FROM HEAT TO MECHANICAL ENERGY

more than two tons of wood, and at half the cost. The development of America's steel industry in the late 1860s gave coal another big boost. By the 1870s, coal-generated steam surpassed water as a source of power for industry, and by the 1890s steam was beginning to generate electricity. The census of 1890 recorded a population of 63 million. As industrialization advanced, new technology increased production, but most factories were still located near coal supplies. More machines required more energy to power them.

By the mid-1880s, coal was the nation's major energy source, and by 1910 it provided more than 70 percent of the total energy consumed. Even though wood continued to be used widely in homes, coal almost completely took over the energy needs of industry and transportation.

During its 60 years of dominance, coal also was processed to provide manufactured "town gas" for urban lighting and cooking, some liquid "coal oil" for kerosine lamps, and the coke needed for steel production.

DRAKE'S FIRST OIL WELL

As more railroads were built, they converted from wood to coal, and their expansion increased the demand for coal, which could be transported for use almost anywhere. In addition, the iron and steel industries were using vast amounts of coal, which in turn required more rail transportation from iron and coal mines to the industrial centers. Mass production techniques ushered in a new age of more goods for everyone.

The demand for electricity increased rapidly in the early years of this century, and it replaced kerosine and gas lamps in most metropolitan areas. Water power drove many of the early hydroelectric generators, but coal was used more and more to fuel steam-powered generating plants. By 1920 the population exceeded 106 million and, though coal was king, its energy share began a slow decline as another fuel became increasingly popular—petroleum. The switch was triggered not by a shortage of coal — which was and still is in abundant supply — but by the attractions of oil and natural gas. Petroleum products, readily transported, versatile, and relatively clean burning, gradually replaced coal as the major energy source of the twentieth century.

THE FOLLOWING AMOUNTS OF PRIMARY ENERGY SOURCES SUPPLY ABOUT THE SAME AMOUNT OF HEAT:

6,000 barrels of oil

2,800,000 pounds of bituminous coal

38,000,000 cubic feet of natural gas

1 pound of fissionable uranium

First commercially produced in the U.S. in 1859, crude oil was primarily refined into kerosine for lighting, and as lubricants for machinery. By 1870 oil had become the country's second biggest export product. But it took another 40 years for oil to come into its prime.

Henry Ford's mass production techniques, developed between 1905 and 1920, brought the cost of an automobile within the reach of millions. The demand for gasoline increased rapidly as more and more cars were built each year. By 1976 there were 100 million motor vehicles on the road.

Development of the internal combustion engine stimulated the production and use of enormous amounts of gasoline and diesel fuel. The population grew to 123 million Americans in the 1930 census. By the 1940s diesel engines were replacing coal-burning steam engines and were being adapted in ships, buses, trucks, and tractors. Cheap and plentiful liquid fuel led to rapid growth of all types of vehicles, especially the automobile.

Extensive natural gas pipelines were built in the 1950s to supply gas to the nation's major cities. Natural gas became popular for heating homes, powering electric turbines, and for many industrial purposes.

Oil and natural gas have dominated the energy market since the 1950s. Reliance on these fossil fuels to meet an ever rising energy demand depleted proved reserves, and petroleum imports were needed to supplement domestic production. In 1955, for the first time, America became a net importer of oil, and from that date, consumer demand caused an ever increasing flow of foreign crude oil to our shores. By 1973 we imported more than 35 percent of our petroleum — an amount equal to our total consumption in 1950. Once burned, these concentrated storehouses of energy are gone forever.

Today, we draw our energy from a variety of sources, primarily from fossil fuels, nuclear fission, and running water. In the past few years, however, we have been forced to realize that fossil fuels are finite and that we have been wasteful with energy resources that had previously seemed limitless. Now we must use these fuels more wisely and develop new sources of energy.

Encourage students to discuss the causes of the transitions from wood to coal and from coal to petroleum. What effects did the transition have on society? What energy sources do students think will replace petroleum if it becomes too scarce or expensive to use for fuel? What are their reasons? What effect will these new energy sources have on society?

We still have large supplies of coal, but use it for less than 19 percent of our energy. Electric power from water is limited by the lack of suitable sites; only 4 percent of our energy is from hydropower, a figure that is not expected to grow significantly. Nuclear power plants will continue to produce more electric power but the increase will be slower than anticipated.

Today, most of the things we do, and all of the products we use, rely on considerable energy input—mostly from non-renewable fossil fuels. As fossil fuels become depleted, other energy sources must be found to replace them. Only about 7 percent of our currently consumed energy sources are renewable.

With a population of more than 220 million in 1980, petroleum provided about three-quarters of our energy (48 percent from oil and 26 percent from natural gas). It is accurate to say that America runs on petroleum. This shift to almost total dependence on finite, nonrenewable energy sources occurred in less than a hundred years.

The sun, wind, tides, fusion, magnetohydrodynamics, geothermal, oil shale, photosynthesis, bioconversion,

ocean gradients, and other forms of alternative energy are being investigated, but it will be years before any of them really begin to pay off. Methods must be found to convert, produce, and use these potential sources economically and in environmentally accepted ways. In the meantime, we must use what we have more efficiently and learn how to conserve our nonrenewable supplies of coal, oil, natural gas, and nuclear power. How we manage these resources over the next few decades is important to everyone.

ADDITIONAL ACTIVITIES

1. Suggest students keep an energy file. Clip pictures and articles from newspapers and magazines: conservation tips, resources, supply and demand, costs, alternatives, ecological considerations. The information gathered can help them complete future assignments. Some clippings can be shared by posting them on an energy bulletin board.

2. People will be concerned about energy for many years to come. They wonder if there will be enough in 20 to 30 years as the world population grows and more energy is needed. Our dependence on imported petroleum, especially oil, makes the United States subject to the instability of political and economic conditions in other countries.

   Events influencing petroleum products and energy production in general occurred so rapidly in the 1970s that people have difficulty learning the facts and understanding the interrelationships between energy production, energy alternatives, and the effects of environmental regulations, price controls, and economics. Students can investigate and write papers, present reports, or debate these points. Perhaps students could begin gathering information on the following topics now, and develop papers as they progress through their study.

   a. **Will there be enough energy?** This topic considers energy currently available and projected supplies over the next 30 years. Included would be a discussion about the economic needs and costs for energy, an analysis of the scarcity and choices of energy, energy production and technology, and the interdependence of nations for energy supplies.

   b. **Who will get it?** This topic considers the productive resources, economic incentives, and efficiencies of energy production. It reviews the market demand for energy used in homes, commercial, industrial, transportation, and electrical generation sectors of the economy. Present energy shares and principal energy sources used would be discussed.

   c. **How will it be shared?** This topic considers the ecological aspects of energy production and use and the conservation requirements that would provide for maximum efficient use of various types of energy. It reviews the opportunity costs and comparative trade-offs between ecology, energy production, energy use, and energy conservation to supply sufficient energy. Suggest matching energy sources to the need and location. Price would be discussed in relation to supply and demand for energy.

   d. **What are the options?** This concerns questions of alternative energy supplies, technological breakthroughs, competitive costs, potential reserves of known energy sources, and resource availability based on present and projected consumption. The need for continued major investments in exploration, production, research and development would be reviewed.

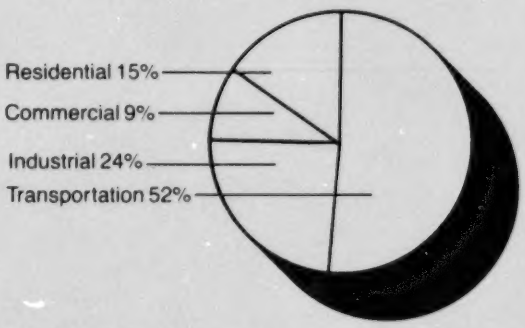
   e. **Who will control it?** Concern with energy production, processing, transportation, and distribution centers on performance and price. This would discuss past and present performance of energy companies versus government controls and allocation mechanisms, and how energy has affected economic growth.

   f. **Politics and energy policy.** This would review the performance of the political system in formulating U.S. energy policy. Discuss how energy is supplied in a free market economy. Taxes and regulation of energy supplies would be reviewed. Effective consumer and industry conservation efforts would be explored.

ACTIVITY 2

Petroleum — From Fossil To Flame

U.S. Oil Use by Economic Sector



STUDENT OBJECTIVES

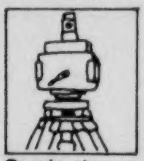
As a result of completing this activity, students should be able to:

- Understand and describe the steps required to get oil from the ground, process it into useful products, and transport them to customers.
- Name some common products made from petrochemicals.
- Recognize and identify the terms "oil shale" and "tar sands," and briefly explain how oil is extracted and processed from them.
- Make some informed comments on the relation of oil to our energy future.

PRINCIPAL TOOLS AND TECHNIQUES USED TO FIND OIL

Surface mapping

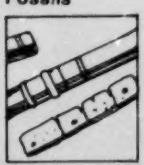
Seismograph



Gravimeter

Magnetometer

Fossils



Cores samples

BACKGROUND AND TEACHING SUGGESTIONS

In this lesson, students discover the relative importance of the oil industry to U.S. energy consumption.

Before class begins, write the following on the chalkboard but omit the connecting lines. You may want to change the order and make a puzzle by asking students to guess the tasks that the varying amounts of oil could accomplish.

1 barrel of oil = 42 U.S. standard gallons

1 barrel	• enough energy to heat an average American home to 68°F during four days of freezing weather.
10 barrels	• enough energy to move the family car from coast to coast and back.
100 barrels	• enough energy to fly a commercial jet from Washington, D.C., to Chicago.
10,000 barrels	• enough energy to meet the needs of the city of Baltimore for 10 minutes.
1,000,000 barrels	• enough energy to supply all of California's energy needs for about eight hours.

Students should analyze the data and indicate where the connecting lines should be drawn to correct each statement. After the lines are added, most will agree that the U.S. uses a great deal of oil. Reinforce this point with one more statistic: 8,000,000 barrels = daily U.S. oil imports in 1979. This represented about 35 percent of our oil requirements. Domestic sources supplied the rest. Truly, the United States runs on oil. It fuels our transportation system, runs our industry, and heats many of our buildings.

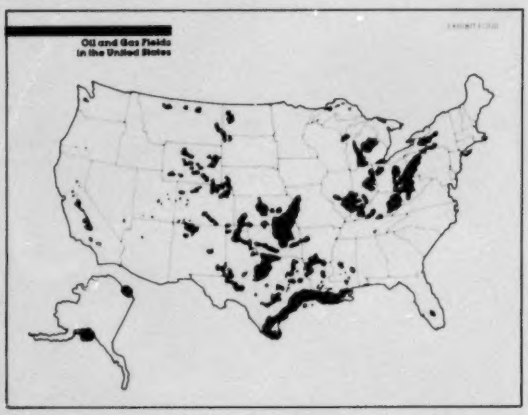
Formation. Petroleum is a fossil fuel derived from the remains of countless organisms that lived millions of years ago. During various geological changes, plant and animal remains were buried beneath layers of mud, silt, and sand that compressed into sedimentary rock. Over eons, decay, heat, and pressure changed the organic matter into liquid crude oil and vaporized natural gas. Relatives of petroleum also exist as bitumen tar sand concentrations and as kerogen found in oil shale deposits.

As petroleum formed, it was trapped in tiny pores within the layers of sandstone, limestone, or shale known as source beds. Many scientists believe the petroleum was squeezed upward into the source beds by the natural pressure of underground water and gas. Dense, nonporous rock formations above the source beds stopped the petroleum from moving to the surface. The dispersed crude oil globules and natural gas are stored within the porous sedimentary rock, similar to the way water clings to the surfaces of a sponge. Folding or faulting buckled the formations, causing the geological traps where petroleum is often found. These underground source bed formations and reservoir traps are the object of the geologists' and geophysicists' search.

Exploration. Exploration's aim is finding oil, gas, and mineral resources. Geological and geophysical surveys are the first step of exploration.

After securing legal access to land, geologists study the surface of the earth for clues to what lies hidden below. Surveys and charts may help locate source beds, structural traps and faults. Accumulated knowledge and computer data assist in evaluating potential petroleum sites. Geophysicists review magnetic, gravity and seismic data, as well as core samples from drilling, to map the underground structures. If a team of geologists, geophysicists, engineers, technicians, and scientists makes the recommendation to drill, management evaluates their proposals to determine if the economic risks are justified. The only sure way to find oil or gas is by drilling a well.

A student or group of students can review the prehistorical geologic changes that took place on the earth — particularly on the North American continent — and prepare drawings or diagrams to demonstrate how petroleum was formed. Other students can prepare discussions about the structural formations that may indicate the presence of petroleum, while still others may investigate and report on methods used to find these structures. Another group can research and report on the location of petroleum resources throughout the world. Review the map — Exhibit 4, Oil and Gas Fields in the United States.



Leasing. When the geologist recommends leasing a specific area that might contain petroleum, an oil company land agent negotiates a lease for seismic testing, possible drilling, and the underground mineral rights. The lease includes permission to explore for, drill for, and produce petroleum. Terms vary, but a lease is generally maintained as long as there is the possibility of finding and recovering oil or gas.

Land may be leased from corporations and private landowners, who receive an initial cash payment and royalty percentage for any oil or gas produced. It is an extremely competitive operation with bids for land in promising areas sometimes reaching thousands of dollars an acre. Some petroleum reserves cover many acres where all of the landowners involved have an interest in the same reservoir.

Today, about 20 percent of the total land area of the U.S. is either producing oil and gas or is under lease for exploration. About three-fourths of the land under lease is privately owned.

Public lands are also leased for exploration and drilling from federal or state governments through competitive bidding that often totals millions of dollars. Currently about 13 percent of federally owned public land and 2 percent of the outer continental shelf offshore areas have been offered for petroleum exploration leasing. Despite their relatively small size, in 1979 these areas produced 16 percent of the country's oil and natural gas liquids and 30 percent of its natural gas. Greater access to the vast unexplored lands owned or controlled by the federal government offers significant opportunities for the discovery of new petroleum reserves.

Drilling. After land is leased, an oil company must drill on it to determine if commercial amounts of petroleum are present. Drilling technology has made astounding advances since the first successful commercial oil well in the U.S. was drilled near Titusville, Pennsylvania, in 1859, by Colonel Edwin L. Drake, who struck oil at a depth of 69 feet.

Preparing a site for drilling may be a major engineering project. Often roads and bridges must be built, and drilling rigs flown in to less accessible areas. Most drill rigs are portable and built to permit quick assembly and disassembly.

Rotary drill bits range in size from less than 4 inches to 22 inches in diameter and have hundreds of hard, sharp steel teeth. The kind of rock determines the type, shape, and size of the drill bit. Some are studded with industrial diamonds to help penetrate extremely hard rock formations. All contain perforations through which mixtures of specially prepared chemicals, water, and a mud slurry are pumped. These liquids, called "drilling mud," cool and lubricate the bit, control pressures within the well, bring formation cuttings to the surface for analysis, and seal the strata to prevent cave-ins on the well wall. The bit and the hollow drill pipe, serving as the drill shaft, are rotated by a diesel powered turntable.

As the drilling progresses, additional sections of drill pipe, each about 30 feet long, are connected to reach into the depths. Each time the drill bit becomes dull, all of the drill pipe must be removed, the bit replaced, and all of the pipe rejoined and lowered again. Modern drilling techniques use "blowout preventors" and the oil gushers seen in old movies are a thing of the past.

Most shallow oil and gas reservoirs have already been found. Wells are now drilled deeper and deeper and at much greater costs. The deepest U.S. well, drilled in Oklahoma in 1974, was more than five miles deep — a 31,400-foot dry hole. The average depth of wells on land is nearly 5,000 feet, while offshore wells average 10,000 feet. The first major well to successfully tap an undersea petroleum deposit was drilled in 1947, off the Louisiana coast, from a platform in the waters of the Gulf of Mexico.

Appoximately 50,000 oil and gas wells and dry holes are drilled annually. Besides drilling to greater depths, oil companies increasingly send people and equipment to remote areas, and this heightens problems — and costs — greatly. Offshore drilling, for example, requires movements of tremendous amounts of equipment by barge, ship, and helicopter to platforms moored at sea. Drilling in remote areas like Alaska's North Slope involves a host of environmental problems that must be overcome — at costs up to ten times those of drilling in easily accessible areas.

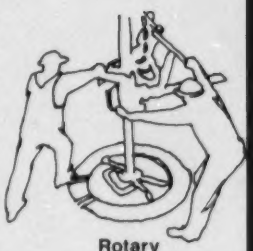
Students can get a better perspective of the tremendous depths reached in petroleum exploration by a graphic example. Oil rigs range from 85 to 175 feet in height. Assume that a typical oil derrick extends about 100 feet into the air. Make a cardboard derrick one inch high. Then have students indicate the depth of a 10,000-foot well by using a length of string cut to scale. If the derrick in their representation is one inch high, the string will have to be 100 inches long. If the derrick is only one-half inch high, a chalkboard drawing will show a line more than four feet long to indicate the well depth.

If no oil or gas is discovered after the drill has passed through potentially productive formations, the equipment is removed, the site is cleaned, and the well capped and abandoned. The odds are six to one against the possibility that the driller of an exploratory well in an unproved area will find any oil or natural gas in commercial quantities. Of the more than 2,500,000 exploration, development, and production wells drilled in the U.S. since 1859, about 25 percent have been dry holes.

Production. If a discovery's size merits additional investment for commercial production, the drill pipe is removed and replaced with hollow, high-strength casing pipe which is cemented in place.

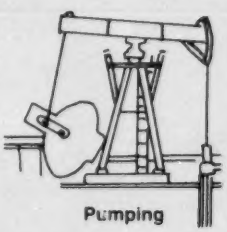
When the oil is brought to the surface by natural pressure, the drilling rig is removed and replaced by a valve assembly called a "Christmas tree" to regulate the flow. When pressure is low, pumping units raise the oil. Today, oil wells are scientifically spaced, and rates of oil flow are carefully controlled to maximize production.

Only about a third of the oil in a given reservoir will flow naturally to an area where it can be pumped out. The oil industry has developed a number of ingenious but costly ways that can conceivably recover as much as 80 percent of the crude oil in place. One method pumps acid into the reservoir to dissolve channels through the rock in which the oil is embedded. Another technique, fracturing, pumps treated fluids into the well under high pressure to split fissures in the rock. Often water, carbon dioxide, or another gas are injected into a producing well to boost pressure and move more oil toward the wellhead. Still another method uses detergents or solvents designed to loosen or dissolve the oil from the porous rock to which it clings.



Rotary Drilling

CRUDE OIL FORMATION



Pumping

Another recovery method involves the injection of steam into the oil reservoir. If fire flooding is used, oil is ignited underground and the fire is controlled and moved by injections of air. Only a small part of the oil in the reservoir is actually burned, but enough heat is produced to move the remaining oil more freely.

Crude oil pumped from a well is sent via gathering pipelines to small centralized storage tanks and then to a refinery by a major pipeline.

Transportation. The location of an energy resource, where it is processed, and where it is ultimately used, affect the choice of transport. The table shows the energy intensiveness of each transportation mode used to move fossil fuels.

Intercity Freight Transport

Transport Mode	*Btus of Energy Used To Move One Ton of Freight One Mile*
Pipeline	450
Waterway	540
Railroad	680
Truck	2,800

Pipelines are obviously the most energy efficient and are used to move large quantities of natural gas, crude oil, and refined petroleum products. Railroads and barges are similar in efficiency, but railroads move materials faster than water transport, and can be located where they are needed. Because trucks are more expensive to operate, they are used for relatively short hauls directly to consumers.

Petroleum transportation is an industry in itself, moving about 17 million barrels of oil products to customers each day. Crude oil and refined products are transported over long distances between producing, refining, and consuming centers.

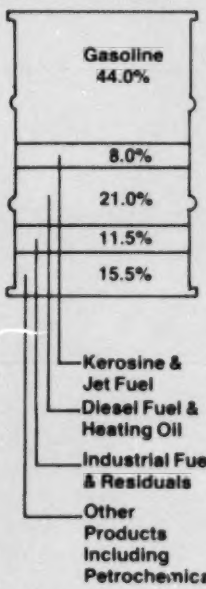
By far the largest volume (60 percent) of crude oil and petroleum products is moved through the 227,000 miles of pipelines that crisscross the country, ranging from 2-inch diameter gathering lines to 48-inch trunk lines.

Another one-third of the crude oil and refined products are moved by barges and tankers — along the nation's coasts, the Great Lakes, and via the 30,000 miles of inland waterways.

You may want students to review the various advantages and limitations of different means of transportation. Ask students to consider both the geographic limitations and costs of transporting various products. Why are so few petroleum products carried by railroads today? At one time, rail transportation was a major factor in refined products distribution.

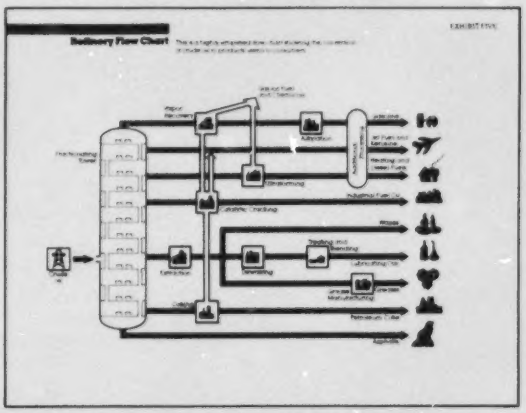
Many consumers receive heating fuels via tank trucks from bulk plants or terminals. Other customers — service stations, commercial establishments, industrial plants, utilities, transport companies, factories, municipalities, and farms — are supplied all types of refined products by truck or rail.

AVERAGE YIELD FROM A BARREL OF CRUDE OIL



Note that two boxes are provided for the paragraph about pipelines in the student activity. In your discussion point out that pipelines are used to transport crude oil from the wells to the refinery and again to move refined products to terminals for distribution to customers.

Refining. Crude oil must be refined to be useful. In refining's early days simple distillation of crude oil produced kerosine, which was used primarily for lighting. It soon replaced whale oil that was rapidly becoming scarce and expensive. Some lubricants were made, but most of the other products — including gasoline — were discarded. Today, refineries convert the complex hydrocarbons of petroleum and natural gas into more than 2,000 products. Nothing goes to waste.



Review or project Exhibit 5, Refinery Flow Chart. The modern petroleum refinery is a maze of towers, tanks, and vessels of assorted shapes and sizes connected by miles and miles of pipe. The initial step in processing crude oil is distillation. In the refining process, crude oil is heated to 650 degrees F, and the mixture of hot vapors, sometimes under pressure, is fed through pipes into the bottom of fractionating towers. Distillation takes place in pipe stills. These units, often 15 to 20 stories tall, are among the refinery's most prominent landmarks.

As the vaporized crude oil rises through a series of perforated trays placed at regular intervals in the fractionating tower, some of the vapors cool, separate, and are drawn off as liquids as they condense at different temperatures. The lighter compounds — called "fractions" — include gases, naphtha, and gasoline. They condense near the top of the tower. Jet fuel and kerosine are next, followed by diesel fuel and heating oils. Lubricants, heavy oils, asphalts, and other residual products are removed near the bottom of the unit.

Most fractions require further processing before they are marketed. For example, cracking involves complex physical and chemical processes, taking place in the presence of a catalyst, to rearrange the molecular structure of petroleum into more useful products. Modern catalytic cracking units make gasoline 7,000 times faster than the original process. In the reforming or polymerization process, platinum is used as the catalyst to combine smaller, very light molecules into larger ones, thereby increasing the yield of high octane fuels. Another process, alkylation, forms high octane components for gas-

oline. Many refineries have about 10 percent leeway to adjust production of gasoline or heating oil, depending on the season of greatest demand or the current needs of consumers.

To emphasize the importance of a catalyst in a chemical reaction, try this demonstration and amaze your students. Take an ordinary cube of sugar. Hold the sugar in metal tongs and expose one corner of the cube to a match or candle flame. Of course everyone knows sugar doesn't burn! But does it? Sprinkle the sugar cube with a few fine cigarette ashes. Again hold it in the tongs and light it with the flame. The formerly inert substance, sugar, is transformed with the addition of a catalyst — in this case, not platinum but ashes, and it now sustains a flame.

Many important catalytic chemical reactions have been developed by some of the 25,000 petroleum research scientists and technicians who work to increase our knowledge of petroleum chemistry and to develop new products for better living.

Petrochemicals. About 5 percent of petroleum components — such as natural gas, propane, butane, and liquid hydrocarbons derived from crude oil — are used to make chemical compounds called petrochemicals. More than 10,000 petrochemical products are in common use, including adhesives, fibers, antifreeze, films, cosmetics, inks, detergents, medicines, dyes, paints, explosives, plastics, solvents and synthetic rubber. You might assign some students to research and list the variety of products made from petrochemicals.

Chemists create plastics by combining petrochemicals, often with the aid of a catalyst, under carefully controlled heat and pressure. Different combinations make plastics that are flexible or rigid, clear as crystal or as colorful as the rainbow. These petrochemical-based plastics are synthetic cousins of natural materials and take over many functions performed by wood, metal, brick, and ceramics.

(Additional information about petrochemicals and plastics can be secured from: Consumer Information, Manufacturing Chemists Assn., 1825 Connecticut Ave., Washington, D.C. 20009, or Director of Communications, Society of the Plastics Industry, Inc., 35 Lexington Ave., New York, N.Y. 10017.)

Marketing. Motorists may choose from up to 30 brands of petroleum products in many states. These products are available at more than 150,000 service stations, self-service units, and convenience outlets. Eight out of 10 retail outlets are owned or operated by independent local business people.

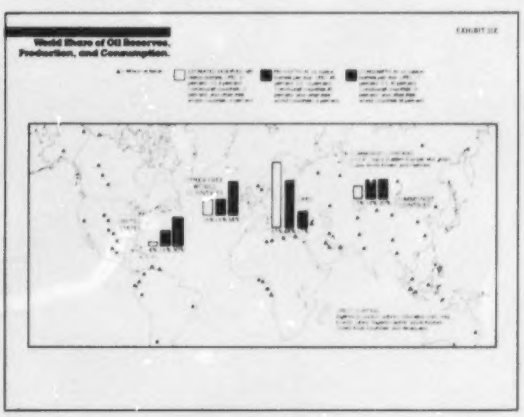
Petroleum marketing has some unique characteristics. Most products are rarely seen by customers. It takes some 50,000 competitive oil companies employing more than 1,650,000 men and women to move and sell a heavy, bulky, rather low-grade commodity. They search for it in the depths of the earth. They lift it out of the ground, put it in collecting tanks, transport it to a refinery by pipeline, tanker or barge, process it, put it in more tanks, load it in ships, tank cars, trucks, or into another pipeline, move it again to a terminal, unload it, reload it, distribute it to a service station, put it in another tank, pump it out once more into the customer's automobile tank, and charge — not including taxes — about 15 to 20 cents a pound. In fact, the average U.S. wage earner works only about 15 minutes to earn the price of a gallon of gasoline, without taxes. What other product requiring all that human labor and energy in its handling can be purchased for anywhere near that price?

The cost of a typical gallon of gasoline sold in the U.S. is composed of: crude oil, 53 percent; refinery and distribution, 20 percent; oil company profit, 3 percent; dealer operating margin, 10 percent; and taxes, 14 percent.

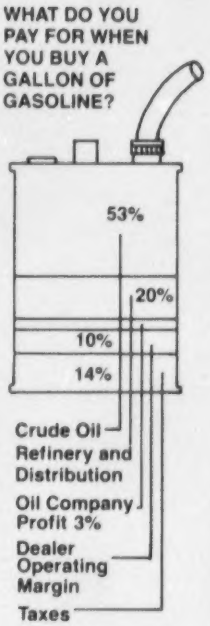
Crude Oil — Supply and Demand. An overview of recent events will help students understand the current energy situation. America had abundant, low-cost, secure supplies of energy between World War II and the 1960s and enjoyed a period of unprecedented economic growth and a rising standard of living.

In the early 1960s, lower-cost oil imports were supplying 15 to 20 percent of our needs. As domestic oil production decreased and demand for oil increased, our dependence on foreign oil increased. Imports rose from about 3 million barrels a day in 1970 to more than 8 million barrels a day in 1980 — 35 percent of the oil we consume. During the same period, the Organization of Petroleum Exporting Countries was able to raise prices because of world oil demand. The U.S. oil import bill increased from about $3 billion in 1970 to more than $90 billion annually in 1980, or the equivalent of about $10,275 an hour.

Review or project the visual aid, Exhibit 6, World Oil Reserves, Production, and Consumption. Discuss the three graphs with students. Note, for instance, that both centrally planned economies* and the U.S. account for larger percentages of world oil production and consumption than proved reserves. On the other hand, OPEC countries account for nearly half of the world's production, and over two-thirds of the world's known proved reserves, but use only a very small portion of the petroleum produced.



*Centrally planned economies are generally located in Communist countries where productive resources are allocated by government agencies rather than through the action of market forces.



The causes for our oil dependence are apparent. We use more petroleum than we produce. We must overcome this problem by formulating a practical oil plan for our future.

The United States is unique among the great industrial nations because of its vast resource base. Government and petroleum industry studies indicate that the U.S. can expect to produce another 150 billion barrels of liquid petroleum. This is more than the U.S. has ever produced and amounts to 40 years of production at current levels. By developing domestic resources on both public and private lands and producing petroleum more efficiently, we can reasonably expect to maintain oil and natural gas production near current levels.

Energy conservation combined with development and use of synthetic and renewable energy resources will help the U.S. reduce its dependence on foreign oil — perhaps by 50 percent — in which case foreign oil would account for only 10 percent of our total energy consumption, just as it did in the 1950s.

On the other hand, if we continue down the same path that we followed through most of the 1970s, imports will continue to increase — assuming that we will pay any price to obtain foreign oil.

In addition to finding and producing more crude oil and natural gas, large reserves of oil shale and tar sands can be developed to increase the domestic energy supply.

Oil Shale is a fine-grained sedimentary rock containing bands of a hydrocarbon known as kerogen. When heated, the kerogen decomposes to yield oil, gases, and residual carbon. Some of the richest oil shale reserves in the world underlie parts of Colorado, Utah, and Wyoming. This formation contains 600 billion barrels of recoverable shale oil. Put in another perspective, the oil shale reserve in these three states equals more than 90 percent of the world's estimated proved reserves of conventional oil.

Two types of recovery are being examined: conventional mining, with processing above ground, and in-situ (underground, in place) technology. After conventional mining, the shale is brought to the surface, crushed and then heated in giant vessels where the kerogen is decomposed into shale oil, combustible hydrocarbon gases, and carbon residue. Approximately 2,000 pounds—one ton — of marlstone shale rock must be processed to make 25 to 35 gallons of oil.

Modified in-situ recovery technology requires some underground mining to remove about one-third of the shale for processing on the surface. The remainder of the underground retort is rubblized with conventional explosives to create the necessary permeability for burning. After ignition, the combustion zone burns and at about 900°F and the shale oil leaves the rock in the form of a vapor. Once released, it condenses into a liquid and is pumped to the surface. After further treatment by hydroprocessing, shale oil is similar to crude oil and can be sent through pipelines to refineries.

The oil industry estimates that shale oil production can be significant within a few years if technical, environmental, and economic problems are overcome.

Tar Sands are a mixture of sand, clay, water, and bitumen — a heavy tar-like hydrocarbon. Although tar sands located at or near the surface can be surface mined, utilization of the deeper deposits may depend on in-situ production. Hot water and steam as well as solvent extraction may be used to separate the tar from the sand and clay. Additional processing upgrades the material to a high quality synthetic crude oil. The largest North American deposits of tar sands are located in Western Canada, and substantial deposits are found in Utah and some other western states.

Distribute the activity sheets and ask students to look at the graph: Major U.S. Primary Energy Sources. Explain that petroleum is a fossil fuel that includes crude oil and natural gas. Ask how much of the energy consumed in this country comes from oil? (45%) How much comes from natural gas? (27%) How much, then, comes from petroleum? (72%) — almost three quarters of our energy consumption. Point out that when coal is added, our total energy consumption of fossil fuels increases to 93 percent.

Students should then complete the activity, identifying each process and putting it in its proper order. Notice that transportation must be considered twice.

ADDITIONAL ACTIVITIES:

1. Have students form committees, each selecting a different phase of oil company operations — exploration, drilling, production, refining, transportation, or marketing—to investigate and report on. Encourage each committee to develop visual aids such as charts, graphs, or illustrations.
2. Review or project Exhibit 4, Oil and Gas Fields in the United States. Point out to students while oil and gas are frequently found in the same reservoir, about 70 percent of the natural gas is not associated with crude oil. Ask students where they think new petroleum fields will be found and why. You may wish to discuss the transportation of oil by pipelines from oil fields to refinery points, and refined product distribution by pipeline to terminals near urban centers.
3. There are more than 3,000 occupations in the petroleum industry. In addition to service station dealers and truck drivers, the industry needs geologists, engineers, oil well drillers, chemists, construction people, typists, accountants, lawyers, managers, computer programmers, supervisors, salespeople, and business administrators. A student group may wish to explore some of the petroleum industry career opportunities.

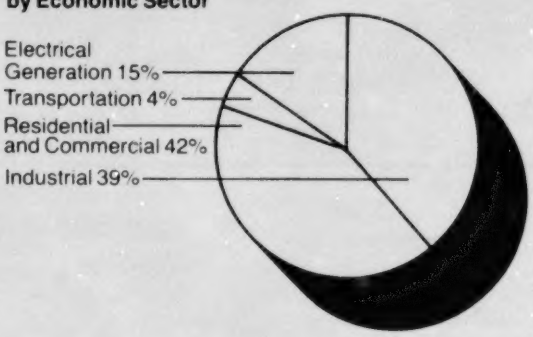
4. Formulate an Oil Plan for Our Future. Using Exhibit 6, World Oil Reserves, Production, and Consumption, have each student formulate an oil plan that would be effective between now and the year 2000. They will need to review potential production from all sources. What will our oil needs be? How will we meet them? How can the customer be best served? Explain that studies indicate the U.S. can expect to produce another 150 billion barrels of liquid petroleum.

Students can be assigned to write short paragraphs about each topic and how they relate to their energy plan: U.S. petroleum resources, new resources like oil shale and tar sands, domestic exploration, increasing or decreasing imports, and the impact of conservation.

ACTIVITY 3

Natural Gas — Clean Convenient Energy

U.S. Consumption of Natural Gas by Economic Sector



STUDENT OBJECTIVES

As a result of completing this activity, students should be able to:

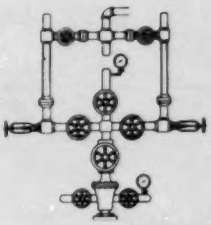
- Distinguish between crude oil and natural gas.
- Describe production, processing, and distribution of natural gas.
- Name the chief component of natural gas.
- Recognize and briefly describe coal gasification, LNG, and biomass resources.

BACKGROUND AND TEACHING SUGGESTIONS

Natural gas, like oil and coal, is a nonrenewable hydrocarbon fossil fuel formed from decayed organic matter which was subjected to heat and pressure over millions of years. It is generally found in porous underground geologic faults and traps. The chief component of natural gas is methane, a colorless, odorless gas that can be burned to release energy. A molecule of methane, CH_4, is composed of one atom of carbon joined to four atoms of hydrogen. Natural gas is found in association with crude oil about 30 percent of the time, and the formation, land leasing, exploration, production, and pipeline transportation of natural gas are similar to the processes associated with liquid petroleum.

Refer to the Teaching Suggestions, page 14, which offer a plan to put much of the background information that follows into the hands of students. You may also wish to review parts of Activity 2 that refer to natural gas exploration and production.

History. The U.S. natural gas industry began in 1821, when William A. Hart, a young gunsmith with an inventive and inquisitive mind, dug a well in the village of Fredonia, N.Y. The relatively shallow, 27-foot-deep well produced enough gas to light four stores and shops and a nearby grist mill. Hart also arranged for the first natural gas pipeline, made of hollow, white pine logs bored with eight inch holes. Within three years the logs were replaced by lead pipes. Deeper wells were drilled to supply more gas, and cast iron pipelines were installed to service more buildings. In 1858 the Fredonia Gas and Light Company was formed, the forerunner of our public utility firms, which generally are privately owned but franchised by local government agencies to provide service to an entire community. The natural gas industry currently employs about 200,000 people.



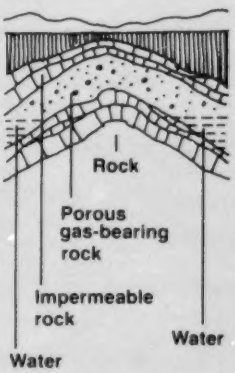
CHRISTMAS TREE VALVE ASSEMBLY TO CONTROL GAS OR OIL FLOW

Supply. Today natural gas provides about one-fourth of total U.S. energy needs — second only to oil. Gas is used to heat more than half of our homes, and it fuels more than 40 percent of the nation's industrial production.

Although projected volumes of gas supply vary with assumptions about future technical, economic, and political conditions, it is reasonable to expect a continuing supply of natural gas for at least 25 percent of the nation's total energy needs during the next 40 years. Studies indicate future natural gas production of about 800 trillion cubic feet — 40 percent more than produced to date.

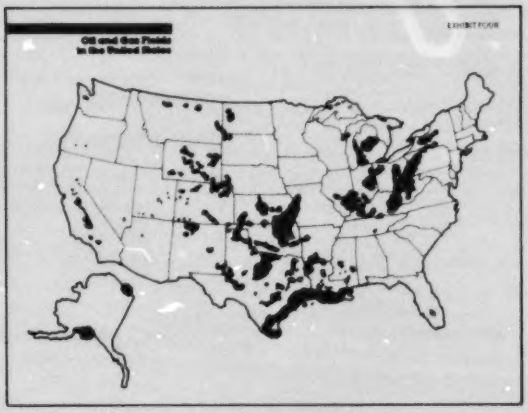
Large new capital investments will be required by the industry to make these gas supplies available. Previously, gas-utility-industry capital requirements were determined principally by the need to build and maintain pipelines and auxiliary facilities. While investment will continue in these areas to ensure efficient, safe, and reliable gas delivery, increased capital will be needed for the development of domestic, supplemental, and synthetic gas supplies. The key to finding more natural gas, like finding more crude oil, is drilling activity. A successful new commercial gas strike occurs only once for every 10 wells drilled.

More than 90 percent of U.S. natural gas proved reserves and production is in six states—Louisiana, Texas, Oklahoma, New Mexico, Kansas, and Alaska. Reserves in these states vary from 12 to 70 billion cubic feet. These six states also produce about 90 percent of the domestic natural gas used. Another nine states have individual reserves of one to five billion cubic feet. Eight other states have smaller reserves, and gas is



NATURAL GAS FORMATION

produced in small quantities in eleven other states. (Refer to Exhibit 4, Oil and Gas Fields in the United States.)



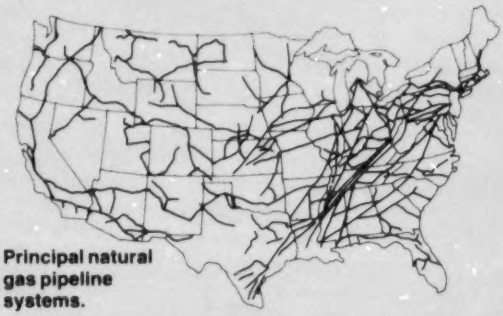
The largest unexplored areas believed to have gas potential are Alaska, the Continental Shelf, and some western states. Much of this territory, including all of the Outer Continental Shelf, is controlled by the federal government. In fact, United States Geological Survey studies estimate that more than 40 percent of our undiscovered natural gas supplies lie under federal lands. As students become voters they will have to decide, through their elected representatives, when and if this land will become available for oil and gas exploration and production.

In most producing areas, natural gas is processed to remove impurities and make it suitable for use in homes and industry. In this processing, valuable by-products are often recovered, such as light oils, natural gasoline, and other gases.

Pipelines. Natural gas is conveyed from the well to the consumer via a vast interstate pipeline system more than a million miles long. The pipeline system follows the three-level structure of the industry: production, transmission, and distribution. It consists of 68,000 miles of underground gathering pipelines, 278,000 miles of transmission pipelines, and 812,000 miles of distribution pipelines, representing a total investment of more than $65 billion.

Producers develop and operate the wells that get the gas out of the ground. The transmission companies operate the large, high-pressure interstate pipelines that deliver the gas from the wells (primarily in Texas and Louisiana) throughout the nation. A welded steel transmission pipeline may be 40 inches or more in diameter. Pumping stations 50 to 150 miles apart compress the gas and force it through the transmission pipeline at about 15 miles an hour at a pressure of 1,000 pounds per square inch. The distribution companies reduce the pipeline pressure to less than 20 pounds per square inch before sending it through mains, which are pipes under the streets connected to smaller pipes, called services, leading to homes and commercial buildings. Gas pressure in service lines is less than one-half pound per square inch.

The distribution companies match the immediate supply of natural gas to demand. Because gas comes from the wells at a constant rate, and pipelines must be kept in use, transmission companies deliver natural gas at a near constant rate year round. Distribution companies collectively have a massive storage capacity. Some excess gas may be pumped into underground reservoirs until it is needed to meet high demand during cold weather. During the winter, residential consumers use approximately five times as much natural gas as in the summer.



Principal natural gas pipeline systems.

Before they can build new pipelines, energy companies must prove to government agencies they have sufficient supplies of gas, usually enough to last 20 years or more. They must also show they have the engineering skills and financial resources to build a line and operate it safely and efficiently. Federal agencies establish the prices for gas and gas transportation, as well as safety standards. The amount of gas sold and delivered is affected by such diverse factors as economic and political policy, the requirements of domestic residential, commercial, and industrial users, and the relative cost of synthetic and imported gas.

Supplemental Sources of Gas. Conventional natural gas production is supplemented by some manufactured, synthetic, and substitute gases. Nonconventional gas sources include methane in gaseous coal seams; gas conversion from biomass materials such as garbage, landfills, and sewage; natural gas in Rocky Mountain tight sand formations and Appalachian Devonian shale formations; methane dissolved in geopressured ocean water; synthetic natural gas from coal gasification; and liquefied natural gas from other countries, such as Algeria. Pipeline deliveries from Alaska, Canada, and Mexico may also become predominant supplemental sources of supply over the next decade. When developed, many of these sources may eventually contribute to the total U.S. gas supply, but they will be considerably more expensive than present natural gas.

Supplemental sources of gas currently provide about 7 percent of the total U.S. gas supply. However, this percentage should increase steadily over the next 20 to 30 years to provide from 40 to 60 percent of the total supply, depending upon economic and regulatory factors. For additional information see Activity 6 — Alternative Energy Sources.

Coal Gasification. The gas industry grew up using coal as its basic raw material. Many major cities once had plants which used coal to make coke and manufacture coal gas. Today's challenge is to develop an economical process to produce large quantities of synthetic natural gas (SNG) from the vast U.S. coal reserves in the cleanest possible manner.

Coal was used extensively for heating from 1890 through the 1940s, at which time oil and gas took over because they were cleaner and easier to handle. Consequently, conversion of coal to more suitable and broadly acceptable forms is desirable. There are two principal coal conversion products — methane gas and liquid hydrocarbon. While each of these products has its advantages in the national energy picture, coal gasification has particular advantages: plants can be built near coal supplies, thereby lowering transportation costs, and gas pipelines can be connected easily to the existing pipeline network.

Coal to gas conversion requires both chemical and physical transformation. Synthetic natural gas can be produced from coal either by mining and processing through gasification plants or by using in-situ underground gasification techniques.

Basic coal gasification is a controlled process of reacting coal with steam and oxygen. A stream of sized coal particles is fed into a high temperature pressurized reactor where oxygen is used to increase the temperature. Additional hydrogen and carbon monoxide are produced by reacting the coal with steam. The resulting chemical reaction produces a low Btu gas. A second costly "methanation" step combines carbon monoxide and hydrogen, in the presence of a catalyst, to produce methane — the major ingredient of natural gas. Various techniques are being tested to determine the most efficient and economical process for future large scale application.

If developed, in-situ coal gasification could significantly expand underground gas production from coal seams that are too deep or unsuitable for conventional mining methods. Underground coal gasification would involve burning the coal near a primary bore hole drilled into the coal seam. The gas produced would flow to another nearby well for recovery. The Btu content of the gas produced depends upon the degree of additional processing required.

Capital costs for a single commercial coal gasification plant are currently estimated at more than $2 billion. The production of pipeline quality coal gas will be determined by the processing economics, environmental regulations, and demand. The cost of gas processed from coal will be higher than the present price of natural gas. As other energy prices rise, coal gasification may provide an abundant supply of synthetic gas.

Liquefied Natural Gas. Liquefied natural gas — or LNG — is also a potential source of supplemental gas supply. By reducing the temperature of natural gas to minus 260 degrees F (– 160 degrees C), 615 cubic feet of gas in the normal vapor state shrink to one cubic foot of liquid, a 1/600 reduction. This technique permits the transportation of large volumes of LNG by insulated tanker ships designed for this purpose. The transportation of LNG over oceans and great distances not suitable for pipelines provides a potential for using the largely untapped resources of natural gas outside North America.

Biomass Resource. Methane gas can be produced from both marine and terrestrial biomass resources formed by solar radiation and plant growth. Biomass includes marine plants and algae, trees, grasses and crops, as well as lumbering and crop residue, sewage, and urban waste — all of which can be converted into methane by anaerobic bacteria digestion. Up to three quarters of urban waste can be used to produce methane. The remaining 25 percent of the refuse, consisting mainly of glass, metals, and ceramics, can be recovered and recycled, depending upon the economics of the operation. Renewable energy sources may ultimately contribute significantly as new technology becomes increasingly competitive.

Government Regulation. A review of natural gas regulations imposed by federal and state legislation indicates some of the complexities and difficulties of attempting to regulate the energy marketplace.

Price controls during the 1970s caused supply reductions in the interstate market, while replacement of gas reserves declined. If prices had been allowed to rise at the same level as competitive fuels, exploration would have been stimulated and conventional domestic natural gas production would probably have remained higher.

Since intrastate markets were free of federal price controls, more gas was used within producing states. Nearly 85 percent of newly discovered natural gas supplies were diverted to non-controlled intrastate markets. This led to gas surpluses in producing states and shortages in some price-controlled interstate markets.

As interstate demand began exceeding price-controlled supplies, federal and some state officials attempted to reduce demand through service curtailments. Regulations often restricted new gas hookups to residences and commercial buildings. Industrial consumers — the lowest priority users in many states — could not purchase dependable gas supplies and shifted to oil.

The Natural Gas Policy Act provides for the removal of price controls on most intrastate and newly discovered gas sold in interstate markets. Although interstate gas coming from wells existing before April 1977 will remain under federal regulation, the cost of new natural gas will be determined by its value in relation to supply, demand, and the costs of competing fuels. Increased reliance on the market system will adjust energy prices based on availability and actual production and replacement costs. Natural gas regulation is a study in itself and would make a good project for an in-depth student report.

A FEW PRODUCTS MADE FROM PETROCHEMICALS

Teaching Suggestions. Prior to using the activity sheet, separate your class into six research groups. Have the groups appoint a spokesperson to report their findings. Students in each group should check current reference works to investigate the topics and answer the questions that follow:

1. *Nature of natural gas:* What is it? How was it formed? What is its chief component?
2. *Natural gas industry:* What is its history? Who owns the industry? How many people does it employ?
3. *Supply of natural gas:* Where is it found worldwide? Where is it found in the U.S.? What are the estimated natural gas reserves?
4. *Natural gas pipelines:* Why are they used? How many miles are used in the U.S.? How does the gas industry supply more natural gas to consumers during periods of heavy demand in the winter?
5. *Uses of natural gas:* How is it used by householders, industry, and agriculture?
6. *New sources of gas:* What is coal gasification? What is LNG? How is gas produced from biomass resources?

Students may find areas of disagreement among experts, particularly in projections of reserves and the amounts of gas estimated to be produced from new sources. Since projections are constantly updated, the base year, available data and interpretation of the data may differ.

During another class, provide time for each research group's report. You may want to compare the findings and positions they take with the information provided in this guide.

ADDITIONAL ACTIVITIES

1. After students have reviewed gas production, the processing facility, the pumping station, the storage facility, the transmission station, and the local distribution utility illustrated on their activity sheets, they should realize that the natural gas industry requires more equipment than personnel. The industry is capital intensive as opposed to labor intensive. Explain that capital in a business or economics context refers to the money invested in all of the tools, buildings, and other materials people use in production and distribution. Ask students to classify the following industries as capital intensive or labor intensive:

   construction (labor) — chemical (capital)
   oil refining (capital) — advertising (labor)

   Have students list several other professions, businesses, and industries and determine if they are capital or labor intensive.

2. Students are familiar with the odor of natural gas used in the home. Since natural gas is usually odorless, a chemical is added so it can be readily detected. Because natural gas is flammable, people should never look for a gas leak with a match, candle, or open flame. If you suspect a gas leak, how can it be found and who should be notified?
3. You may wish to emphasize that although LNG can be transported from overseas, it cannot compete in price with domestic natural gas transported via pipelines. Students can trace LNG production from a foreign country such as Algeria to final consumer use at a farm.
4. Ask students if they can think of some advantages that natural gas has over other energy sources because of the existing pipeline transportation system. Write them on the board as students mention them. The more important ones are listed:

   a. Transportation of gas is highly *efficient*, requiring little energy except for pumping, and only *minor losses* in transport.

   b. Most pipelines are underground, *out of sight*, out of the way, silent in operation, and nearly *impervious to weather* conditions.

   c. Pipeline transportation of gas is *flexible*, cost-competitive, and capable of delivering vast amounts of energy throughout the nation.

   d. Pipelines are a *safe* way to transport a highly volatile substance.

   e. Gas is conveyed *directly* to individual consumers.

   Have students compare the transmission of electricity with the transmission of gas, using the italicized words in the five statements above as points of discussion.

ACTIVITY 4

Consider Coal — The Abundant Fossil Fuel

STUDENT OBJECTIVES

As a result of completing this activity, students should be able to:

- Describe coal-mining techniques, processing, and transportation.
- Mention advantages and disadvantages of using coal as a fuel.
- Explain the potential contributions of synthetic fuels derived from coal.
- State major uses of coal.

BACKGROUND AND TEACHING SUGGESTIONS

Coal powered the Industrial Revolution. It was first mined commercially near Richmond, Virginia, in 1790. By the 1850's coal was the country's principal fuel and remained so for 100 years. Coal is still, on both national and international scales, our most abundant fossil fuel energy resource, accounting for more than three-fourths of known recoverable U.S. energy reserves. The U.S. has more than one-half of the free world's coal reserves and a third of the estimated worldwide coal resources, but coal provides only about 20 percent of our energy needs. Doubling our use of coal could help reduce our continued dependence on foreign oil imports.

Coal Formation. Most coal is an organic rock composed of the decayed and compressed remains of plants that lived in prehistoric swamps and bogs. This organic debris gradually sank and was buried by sedimentation. Biochemical decomposition and geophysical processes slowly transformed and fossilized this compacted mass of organic material into various forms of coal. Since plants form carbohydrates and other carbon compounds during the process of photosynthesis, coal is really a concentrated form of chemically stored solar energy. The several forms of coal are usually measured by their heat content.

Peat — very low heating value, wet, spongy brown mass, partially carbonized. Initial stage of coal formation. After drying it can be burned but it is smoky.

Lignite — low to medium heating value (about 7,000 Btu per pound), soft brownish-black coal containing 15 to 30 percent moisture, approximately 40 percent carbon. Has a high ash content. Primary deposits are found in North Dakota, Montana, Texas, and Louisiana.

Subbituminous — medium heating value (about 10,000 Btu per pound), soft black coal containing 15 to 30 percent moisture, approximately 55 percent carbon. This abundant low-sulfur coal is found primarily in Colorado, Montana, New Mexico, North Dakota, Utah, and Wyoming. These states produce 70 percent of all western coal.

Bituminous — medium to high heating value (about 13,500 Btu per pound), soft black coal containing 2.5 to 15 percent moisture, approximately 75 percent carbon. This abundant coal is found primarily in the Appalachian area and midwestern states located east of the Mississippi River.

A typical grade of bituminous coal contains about 75 percent carbon by weight, 5 percent hydrogen, and 20 percent other minerals and undesirable materials. A ton of bituminous coal (at 12,300 Btu per pound) contains about as much energy as 4.3 barrels of crude oil or 23,400 cubic feet of natural gas.

Anthracite — high heating value (about 14,000 Btu per pound), hard shiny coal containing 3 to 5 percent moisture, approximately 80 percent carbon. Most anthracite is mined in Pennsylvania.

Underground Mining. About 40 percent of the coal is extracted by underground mining. The balance is surface mined. Most eastern coal deposits 200 feet or more deep are mined underground. West Virginia, Pennsylvania, and Kentucky are major coal producing states. Illinois, Indiana, and Ohio are important midwestern producers.

Where the coal is exposed, mining begins directly into the coal seam. Otherwise vertical shafts or sloping tunnels are dug to the coal level where mining can begin. These shafts are used to move workers, materials, and air into and out of the mine.

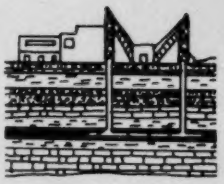
Conventional Deep Mining produces about one-third of the coal mined underground. At the face of the coal seam, holes are drilled into the exposed surface. Then a machine resembling a chain saw with a 10-foot blade cuts a long slit along the base of the coal. Compressed air or explosives are used to break up the coal. Miners control a loading machine which has steel arms to sweep the coal chunks onto a conveyor belt or into shuttle cars. As mining progresses long steel bolts are inserted in the ceiling to support the roof. Crews work in rotation, as there is usually space for only one group at the exposed coal face. To make the best use of machinery and manpower, several tunnels may be mined simultaneously.

Continuous Underground Mining produces more than half of the coal mined underground. Mining machines cut through the coal layers with revolving steel teeth. Coal is removed from the seam and loaded for transport from the mine in one operation. Using a continuous mining machine, one worker can dig as much as 12 tons (11 metric tons) of coal a minute. The machine digs and loads coal faster than it can be removed from the mine, so it is stopped often to let loading and roof bolting operations catch up.

Both conventional and continuous underground mining use the room and pillar method of mining. As the coal is removed, rooms are cut into the coal-seam with pillars of coal left in place to support the roof. Tunnels 14 feet to 20 feet wide intersect like city streets every 40 feet to 80 feet. Some pillars may be removed later, increasing the coal recovery. Depending on the engineering principles used, the supporting pillars often represent half of the coal left in the mine.

Longwall Underground Mining permits removal of up to 80 percent of the coal. This method employs self-advancing hydraulic supports to prop up the mine roof while large, mechanical shears cut out the coal and place it on a conveyor. As the roof supports move forward, the unsupported overburden is allowed to collapse safely behind the area where miners are working. Because of the nature of geological structures and the large capital investment, only 5 percent of U.S. coal is mined by the longwall method.

Surface Mining is usually used where coal is within about 150 feet of the surface. It is safer, generally more economical, and on average three times more productive than deep mining, recovering up to 90 percent of the coal. Surface mining currently accounts for about 60 percent of U.S. coal production. In most surface mining, huge dozers first remove the overburden of soil and clay. Then explosives are used to shatter rock overburden, which is removed and placed to one side. The exposed coal, in seams up to 120 feet thick, is broken up, loaded into trucks, and hauled away.

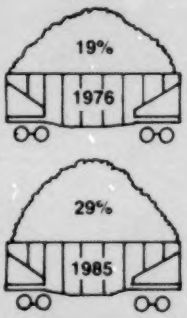


SHAFT MINE

CONTINUOUS MINING

SURFACE MINE

THE SHARE OF COAL IN ENERGY PRODUCTION



It is predicted that coal will produce an increasing percentage of energy in the future.

Many new surface mines are located in the western part of the country. By the time the coal produced in these mines is shipped to customers in the East, transportation costs can boost the base price substantially. A ton of western subbituminous coal has about three-fourths of the energy of eastern coal, but its lower sulfur content permits burning with less expensive pollution control equipment.

Area Surface Mining uses power shovels as tall as 20-story buildings to clear away the overburden. They pile it along the side of a deep ditch, called a cut, forming a ridge or spoil bank. The exposed coal is then removed, and the overburden from the second cut is piled into the first cut and so on. The remaining long parallel ridges are leveled, and the land is returned to its approximate original contour and reseeded or replanted with suitable vegetation to prevent erosion.

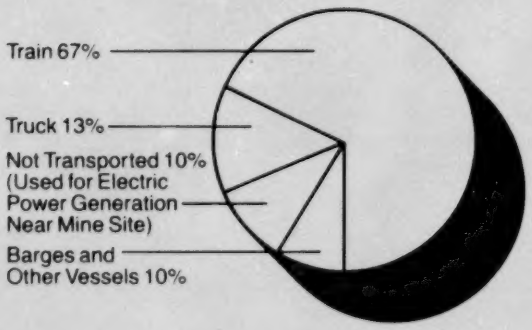
Contour Surface Mining involves basically the same procedures as area surface mining, but the cuts are made around sloping hillsides at the level of the coal seam. It is difficult and often impossible to restore the surface area to its previous condition after this type of mining.

Auger Mining may be used to supplement contour mining. A coal auger, shaped like an enormous screw, can bore up to 200 feet into a hillside to reach the coal seam and twist out chunks of coal.

Coal Mining Problems. Uncertain market conditions, land use and environmental impact issues, air emission standards, pollution controls, licensing, government regulation, and transportation are some of the big imponderables in coal's future. It often takes five to eight years to secure permits, obtain equipment and develop production at a new surface or underground coal mine. The coal industry is working to develop more efficient, economical, and environmentally acceptable systems for mining and using coal.

Coal Transportation. Unit trains currently transport about two-thirds of all coal mined, and they are expected to continue carrying the bulk of our coal throughout the next decade. As production increases, railroads must provide additional equipment and facilities to handle the coal.

How Coal Is Transported



The most efficient and least expensive means of transporting coal is by water. However, navigable waterways are not always available where coal is mined or where it is needed. Although trucks transport 13 percent of the nation's coal, higher costs limit most truck hauling to short distances between rail or waterway terminals and smaller consumers.

A possible alternative to railroad transportation is the use of coal slurry pipelines. These underground pipelines carry crushed coal mixed with water. One coal slurry pipeline in commercial operation transports almost five million tons of coal annually from northeastern Arizona to southern Nevada, a distance of about 275 miles.

One problem in developing this means of transportation is to secure and maintain a sufficient water flow, dispose of the water after it is used, or recirculate the water for reuse, all costly operations. Depending upon its source, the water may turn out to be a more valuable asset than the coal. Approximately one ton of water is required to move a ton of coal.

Developing Technologies. Most coal is used as it comes from the mine, but it can be processed to improve its fuel qualities. In addition, because coal is a hydrocarbon, it can be converted into either a gas or a liquid. Significant new production of synthetic fuels is feasible, but coal's future role depends on the results of current research and development to improve direct combustion and processing techniques.

Fluidized Bed Combustion. The desire to reduce pollutants and improve coal fired boiler efficiency led to fluidized-bed furnace design. Pulverized coal is blown on top of a granular noncombustible material, such as limestone, and suspended or floated by upward blasts of pressurized air. This causes the mixture to behave like a turbulent fiery liquid-like suspension and provides more efficient combustion.

Synthetic Fuels from Coal. Coal is largely carbon, containing only small amounts of hydrogen, oxygen, sulfur, and nitrogen. To convert coal into more useful synthetic fuels, more hydrogen must be added to the carbon atoms.

Synthetic Gas can be made from coal by the addition of hydrogen. One method reacts coal with steam to form carbon monoxide and hydrogen, which are then combined in the presence of a catalyst to make methane, the chief component of natural gas.

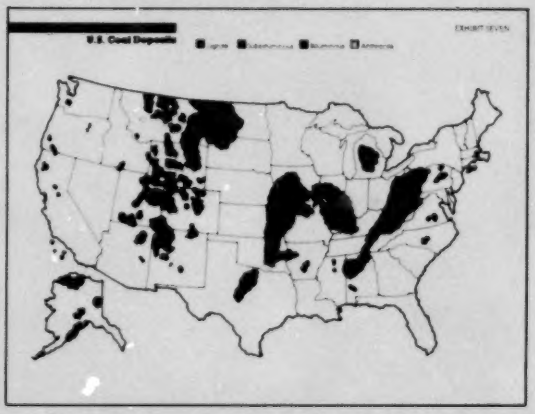
Solvent-Refined Coal. Another process under development produces a uniform, solid fuel that burns hotter and cleaner than raw coal. In the Solvent Refined Coal (SRC) process, crushed coal is mixed with a liquid oil solvent. The coal slurry, heated in a pressurized catalytic reactor with a hydrogen-rich atmosphere, picks up some of the additional hydrogen as it dissolves into the solvent. Impurities, including most of the sulfur, are filtered out and the solvent is recovered and recycled. The remaining fuel is a hard, brittle, tar-like residue having high energy value.

Coal Liquefaction is a complex chemical process based on the interaction of hydrogen and a slurry of coal particles. Coal can be crushed to a powder and decomposed with heat at a high pressure to produce a liquid fuel. The three basic processes under development are hydrogenation, pyrolysis, and catalytic conversion.

Coal use can be increased sharply in the next 10 years without damaging the environment. Most coal is either used for generating electricity or converted to coke which is used in making steel. Although many political and economic problems remain to be solved, the basic technologies have been developed for mining and using coal safely. Land reclamation techniques, electrostatic particulate-removing precipitators, and stack gas scrubbers are all helping to improve the environmental acceptance of coal.

Teaching Suggestions. If possible, get a sample of coal for display in the classroom on the day you introduce this activity. Some students may never have handled coal. If you are familiar with coal heating, share your memories with students: the delivery of coal into the basement coal bin, the problem of starting a coal fire with kindling, the task of removing clinkers and ashes, banking the fire at night, etc.

List the several forms of coal on the chalkboard: lignite, subbituminous, bituminous, anthracite. Peat is not considered a major form of coal because of its low heating value. Then project Exhibit 7, U.S. Coal Deposits, so students can see where the various forms of coal are located in relation to major industrial markets. Are there any coal mines close to your area?



Ask students to list the principal uses of coal. Remind them that less than one percent is being delivered for home heating. Now distribute the activity sheet and draw their attention to the pie chart to reinforce their understanding that most coal is used to make electricity. It is used for the production of industrial process steam and converted to coke for manufacturing iron and steel. Then ask students to read the Coal Facts and answer the questions.

ADDITIONAL ACTIVITIES

1. Let each student pick one synthetic coal conversion process to research, reviewing possible geographic locations, government restrictions, environmental problems, resource availability, product costs, etc.
2. Have groups of students select one facet of coal production from those discussed, and present an in-depth report.
3. Have students research the energy needed to maintain the environmental quality of a coal-burning generating station using electrostatic precipitators, stack scrubbers, and any other pollution control equipment required. The analysis should include energy used to dispose of and transport the waste products.

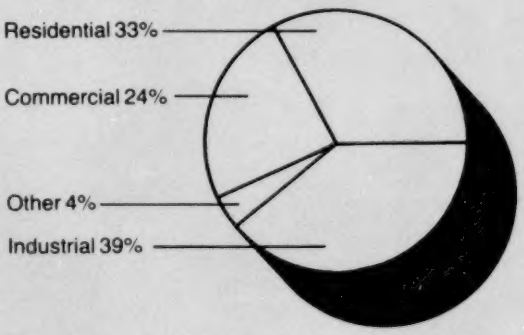
ESTIMATED RECOVERABLE COAL RESERVES

United States:	**30.8%**
USSR:	**23.1%**
Europe:	**21.4%**
China:	**13.5%**
Rest of Asia	**3.0%**
Oceanic:	**4.2%**
Africa:	**2.6%**
Canada:	**0.9%**
Latin America:	**0.5%**

ACTIVITY 5

Electricity– Our Versatile Energy Servant

U.S. Electric Energy Use by Sector



STUDENT OBJECTIVES

As a result of completing this activity, students should be able to:

- Explain the difference between primary and secondary energy sources.
- Name the primary energy sources used to generate electricity.
- Explain how electricity is generated and transmitted.
- Evaluate which energy source best meets the needs of electricity generation in their area.

BACKGROUND AND TEACHING SUGGESTIONS

Electrical Energy. All objects are composed of atoms. An atom consists of a positively charged nucleus with negatively charged electrons revolving around it. Static electricity is created when electrons are removed from some of the atoms which are located on the surface of an object. Current electricity, on the other hand, is created when electrons are forced along a conductor such as a wire. There are two kinds of current electricity —

NUCLEAR FUEL PELLET
A single pellet of nuclear fuel contains as much energy as a ton of coal.

direct and alternating. Direct current (DC) always travels in the same direction and often uses the chemical energy stored in a battery or voltaic cell to move electrons. Alternating current (AC) is usually produced as the result of the force of a rotating magnetic field that induces current in a generator.

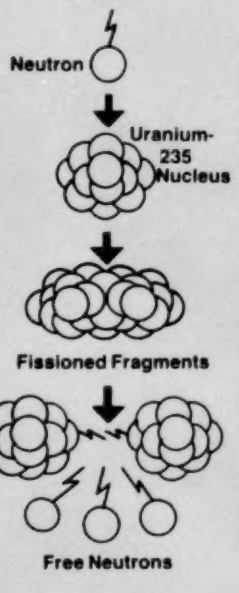
History. The age of electricity began a little more than 100 years ago in 1879, when Thomas A. Edison invented the carbon filament incandescent electric light. In the 1880s he invented or improved numerous other electrical devices — electric generators, motors, distribution systems, meters, controls, fixtures, batteries, and electrical appliances — which have brought about vast changes in the way people live.

Coal fueled the first commercial Edison electric generating station, established in New York City in 1882. As demand increased, the mix of energy sources used for electric power changed to reflect their availability supply and relative cost.

Electricity Generation. Most commercial power generating stations depend upon turbine electric generators. A turbine is a machine consisting of a series of curved fins or cupped vanes attached to the shaft of a generator rotor. Jets of water or pressurized steam rotate the turbine vanes at high speed. In the case of steam turbines, the energy stored in fossil fuels or nuclear energy is used to heat water to produce the steam. Turbines can also be driven by the force of gases or falling water.

The power of the spinning turbine activates the electric generator, invented by Michael Faraday in 1831. A generator consists of a rotating electromagnet (rotor) surrounded by stationary coils of wire (stator). When the electromagnet is rapidly rotated, an induced magnetic field causes electrons to flow in the stationary coils and electric current is generated for transmission to users. Generating plants have an overall efficiency of 30 to 40 percent. But transmission and conversion losses reduce this to about 25 percent of usable energy.

NUCLEAR FISSION



Electricity Transmission. Generating stations typically produce electric power at about 13,000 volts. Once electricity leaves the power plant its voltage can be changed by transformers for transmission at 138,000, 345,000, or even 765,000 volts. The highest voltage transmission line in the U.S. operates at 765 kV. Higher voltage is transmitted more efficiently over distances of up to 600 miles. At its destination the local utility company substation steps down or reduces the voltage to primary distribution circuits operating at up to 34,500 volts to accommodate different needs of commercial and industrial customers. Utility distribution transformers provide 240/120 volt secondary service for final distribution to other customers.

Nuclear Power. The first commercial nuclear reactor began producing electricity in 1957 at Shippingport, Pennsylvania. By 1973 conventional nuclear boiling water reactors accounted for 4.5 percent of our electrical generation and by 1980 their use had increased to about 11 percent. Nuclear power will probably become a more important energy source in the future.

Students are aware of the controversy — often emotional in nature — surrounding nuclear power. Encourage them to research nuclear power and learn all they can about this complex subject so they can form their own opinions on the basis of knowledge and carefully considered facts. The problems associated with conventional nuclear reactors, as they are presently used, are radioactive waste disposal and safety concerns.

The topic is complex enough to allow for a considerable amount of latitude in terms of the information presented. You will want students to learn about the general theory behind nuclear reactions, the operation of boiling water reactors, the practical differences between conventional and breeder reactors, and the benefits and problems, including the economic and political considerations involved.

Nuclear Fission. There are three basic categories of commercial nuclear reactors which vary in terms of moderator, coolant, and design. Conventional nuclear reactors use the uranium isotope — U-235 — as an energy source. When the nucleus — the core of the uranium atom — is struck by a neutron moving at extremely high speed, it splits into at least two fragments. The fission reaction produces intense heat, radiation energy, and additional neutrons as a part of a carefully controlled, continuous chain reaction. Reactor design may include light water, pressurized water, or high temperature gas models.

Uranium has far greater energy potential than any fossil fuel. For example, one pound of uranium could produce three million times the energy released in burning a pound of coal. In operation, however, a typical reactor uses only a small percentage of its fuel core of 100 tons of processed uranium.

Mining and processing uranium ore is difficult. Even the richest ore, which may be recovered by either surface or underground mining, may contain less than one percent uranium. This ore must be crushed, chemically processed, and refined. It must also be enriched at government facilities for use in commercial nuclear reactors. The amount of fissionable U-235, a rare isotope, is increased to three or four percent and fabricated into reactor core material.

Breeder Reactor. Liquid metal fast breeder reactors produce more fissionable material than they consume. Although they derive their energy from nuclear fission, breeder reactors have the unique capability of converting up to 90 percent of otherwise unusable uranium to plutonium, a fissionable element which can be used to fuel other reactors.

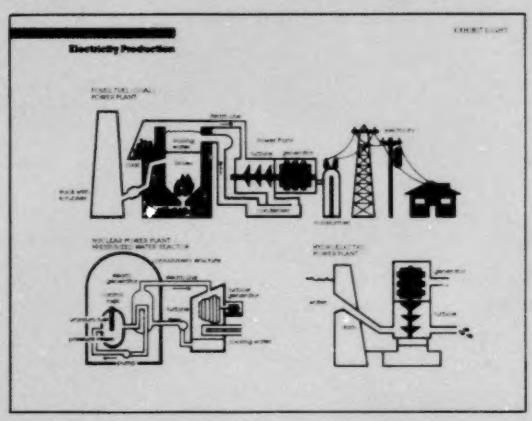
Breeder reactors have a fuel core containing plutonium (Pu-239) surrounded by U-238, a more plentiful but nonfissionable form of uranium. In operation, some of the U-238 is converted to fissionable Pu-239. The breeder reactor produces about five pounds of fissionable fuel for every four pounds it consumes. This would tremen-

dously increase the effective amounts of fissionable materials and make our current uranium reserves sufficient for hundreds of years.

Nuclear Policy. Many scientists and other experts believe that substantial increases can be made in the use of nuclear power if government establishes consistent programs for measured nuclear growth. The technological, safety, security, economic, and social implications of nuclear energy must be developed with special attention to problems of waste management and public safety.

Teaching Suggestions. Begin by asking your class to imagine there is a major week-long electrical breakdown in their community. How will their lives be affected? Begin with the home. Would food storage and preparation change? What about entertainment? Sleeping hours? What electrical appliances could no longer be used? Then expand to their neighborhood and the larger community. What would shopping be like? Would their parents be able to work? What about medical, police, fire, sanitary, and other support services?

Ask students to list the electrical devices and appliances they use in their homes. Discuss and check those they could do without. Then ask which of these items were available when their parents and grandparents were teenagers. This discussion will demonstrate how our reliance on electricity has grown.



Before distributing the activity sheet, project Exhibit 8, Electricity Production. Ask students to compare the similarities and differences between the fossil fuel and nuclear power plants. The big difference, of course, is the energy source and method of producing heat. The basics of steam generated electricity are similar.

Make an overhead transparency of the following chart to discuss the information reviewed in student activity questions two and three.

PRINCIPAL URANIUM ORE LOCATIONS

Electricity Production by Primary Energy Sources (Approximate percent)

		Fuels				
Year	**Hydro**	**Coal***	**Oil**	**Gas**	**Nuclear**	**Power Generated** (Billion kWh)
1922	39	53	6	2	—	61
1932	41	48	3	8	—	99
1942	34	55	3	8	—	186
1952	26	49	8	17	—	514
1962	20	53	5	21.7	0.3	944
1972	16	44	16	21	3.0	1,853
1980	12	48	14	15	11.0	2,250

*Coal includes negligible amounts of geothermal, wood, and waste used to generate electricity.

This chart provides an historical overview. About one-quarter of the primary energy sources produced in the U.S. is used to make electricity. Ask the class what conclusions they can draw from the information. When did petroleum become an important factor in electricity production? Do the most recent figures show a reversal of that trend? Has the position of coal changed much over the last 50 years? Would you expect its use to increase by 1992? Does the decline in hydro power from 39 percent in 1922 to 12 percent in 1980 mean less electricity is being generated from water power? How much more electricity do we use now than we did in 1922? (More than 30 times.)

The use of coal for generating electricity is raised in questions three and five. Because of its cost and availability, coal was the most practical energy source in the 1920s. It is again favored by the electric utility industry, which uses about 70 percent of all coal produced in the U.S. Almost all new power plants planned by utilities will be either coal fired or nuclear reactors. According to the National Coal Association, "For every 10 million tons of coal used in place of foreign oil, the United States can save four million barrels of imported oil."

Contact your local utility to see how your state compares with the chart below. Add these figures in a right-hand column. Although nearly half of all U.S. electricity is produced from coal, energy sources used to produce electricity vary greatly by state and region. Provide or project the following chart for your students to examine.

Primary Energy Sources Producing Electricity — Selected States (Approximate percent)

Energy Source	**VT**	**PA**	**NY**	**GA**	**OH**	**IL**	**LA**	**TX**	**WA**	**US**
Coal	1	75	13	80	95	63	*	25	8	48
Oil	*	9	38	3	2	8	18	2	*	14
Gas	1	*	6	*	*	3	82	73	*	15
Hydro	20	1	25	8	*	*	*	*	88	12
Nuclear	78	15	18	9	3	26	*	*	4	11

(* — less than 1 percent)

Ask students why different areas use different percentages of primary energy to produce electricity. Point out that all but 0.2 percent of our present electrical needs come from conventional energy sources, with only a fraction provided by solar, geothermal, wood, wind, and other nonconventional sources of energy.

Hydroelectric Power. Ask the class how hydroelectric power is indirectly derived from solar energy. Review how the sun's heat evaporates ocean water and moves it in the form of clouds, which condense and fall as rain on the land. The runoff eventually forms rivers. When dammed water is released, the kinetic energy of the falling water spins turbine generators.

The answer to question six is that there are a limited number of sites where rivers can be dammed or where falling water can be used to harness this gravitational force. Water power provides only about 12 percent of the electricity produced, because most locations for dams with high potential are already developed. Environmental and land use considerations may prevent installations at additional locations.

Question eight has to do with the conversion of energy. Students should understand a fundamental law of energy: it can never be converted from one form to another with 100 percent efficiency. Some energy is diverted into less usable forms. In the process of producing, transmitting, and using electricity, from two-thirds to three-fourths of the potential energy produced by the fuel at the power plant is lost between the source and the end use. As a result, it takes three units of fossil energy to produce one unit of electricity.

WHERE WE GET OUR ELECTRICITY

Coal 48%

Gas 15%

Oil 14%

Hydro 12%

Nuclear 11%

ADDITIONAL ACTIVITIES

1. We will rely on fossil fuels, and to some extent nuclear power, to generate electricity for many years. Students can research and then discuss the amount of each primary energy source they think should be allocated for electrical power. A number of factors including availability, location, dependable supply, cost, and the environment must be taken into account. Have students prepare diagrams showing how primary energy sources such as hydroelectric, fossil fuels, and nuclear energy are converted into electricity.
2. Take a poll of students in your class to determine who supports and who opposes nuclear reactors. Arrange a debate in which a committee of pro-nuclear students takes the position to oppose nuclear power, and students opposing nuclear power debate in favor of it. Costs, licensing, safety, environmental impact, hazards, advantages, etc., can be discussed. Afterwards, the class can review the debate and determine which group won.
3. Ask a student or committee of students to report on the storage of electricity in the form of chemical energy — batteries. How are batteries charged? What do they have to do with DC to AC conversion? Are they practical when large amounts of electricity are needed over an extended time? What research is being done?
4. The 18th century was marked by intensive investigation of and experimentation in electrical phenomena. Scientists were fascinated with this elusive force. In fact, many of our electrical and physical terms of measurement are named after these pioneer investigators.

Scientist	Nationality	Unit	Measurement
André Ampère	French	ampere	current
Andres Angström	Swedish	angstrom	wavelength
Marie Curie	French	curie	radioactivity
Michael Faraday	English	farad	capacitance
Joseph Henry	American	henry	inductance
Heinrich Hertz	German	hertz	frequency
James Joule	English	joule	work
Johann Lambert	German	lambert	light
James Maxwell	Scottish	maxwell	magnetic flux
Isaac Newton	English	newton	force
George Ohm	German	ohm	resistance
Wilhelm Roentgen	German	roentgen	radiation
Alessandro Volta	Italian	volt	force
James Watt	Scottish	watt	power

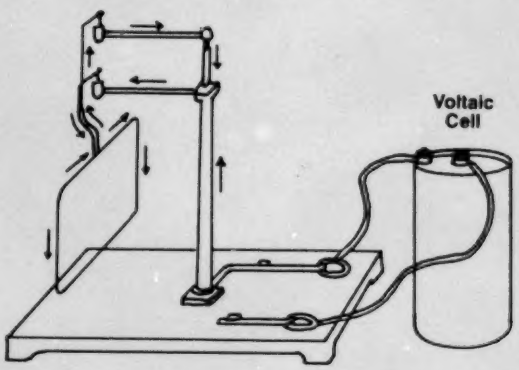
Students may wish to learn more about the scientists whose research led to many of the basic discoveries about the properties of electricity. They can read biographies and write essays or make reports to the class.

5. Invite a local utility representative to speak to the class about the various kinds of energy conversion involved in the generation of electricity. The representative may be able to schedule a class trip to the utility generating station to see the equipment in operation.

AMPERE'S ELECTRIC COMPASS

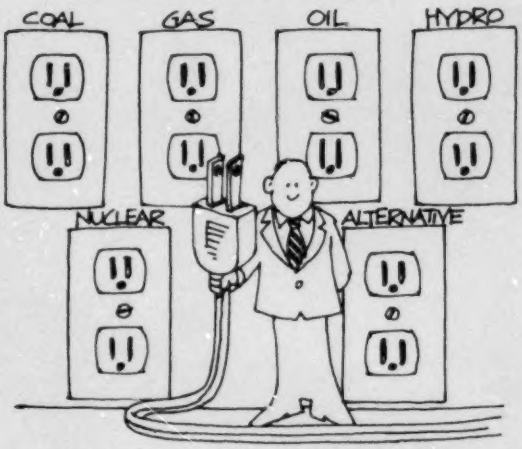
The ampere—a measured of electric current—is named for André Ampère (1775-1836). He was firs. to describe current as movement of electricity along a wire.

Here you see an illustration of Ampère's electric compass. When current from a battery passed along the wire, the wire rectangle could turn to line up with the earth's magnetic field.



ACTIVITY 6

Our Energy Future – Alternative Sources



Where Will Tomorrow's Electricity Come From?

STUDENT OBJECTIVES

As a result of completing this activity, students should be able to:

- Discuss some alternative energy sources.
- Explain the advantages and limitations of each.
- Estimate when various alternative energy sources may contribute to our total energy supply.

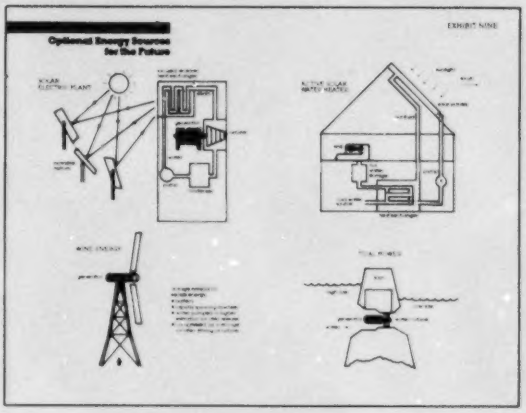
BACKGROUND AND TEACHING INSTRUCTIONS

Because of the finite levels of fossil fuels, it is important to develop renewable energy sources. In 1980, about 4 percent of U.S. energy came from hydropower. Wood and related waste products provided another 0.5 percent. Solar, wind power, and other optional energy sources contributed negligible amounts towards the total energy demands. The reason for this minimal use is economic. Solar or wind energy is not free — devices must be constructed to convert the sunlight or the wind into usable energy, heat, or electricity. The cost of this equipment usually makes solar, wind, and most other alternative energy sources noncompetitive with such conventional sources as oil, gas, coal, or nuclear power.

As the costs of conventional power increase, however, the prospects for using the sun, the wind, and optional energy sources become better. Estimates of the contributions these sources can make by the year 2000 vary widely. It is very difficult to predict accurately what will happen in the next 20 years, particularly with regard to total energy demand and relative energy prices. In the past, society has changed from wood to coal to petroleum as the major energy source with no significant problems, but the period of transition for each has been longer than 20 years.

The best approach is to develop new energy sources for long-term needs as we continue exploration and development of fossil fuels, until supplemental energy sources are commercially available. Increasing conservation will lengthen the time available to develop these sources successfully.

The optional energy sources discussed in this activity have been chosen for the variety of methods they represent, not because of the volume of energy they may eventually provide. You may want to show Exhibit 9, Optional Energy Sources for the Future, as you discuss the alternative sources.



Solar Power appears to be the easiest, least expensive, most environmentally desirable alternative energy source. While radiated sunlight is abundant, clean, and renewable, it must be converted into useful energy. Photovoltaic solar cells convert sunlight directly into electrical energy. Another method, thermal conversion, uses mirrors to track and focus the sun's heat on a central boiler to produce steam for turbine-electric generators. Both systems are presently more costly ways of producing electricity than fossil fuels. If solar power farms were built, rows of tubular collectors would track the sun and heat a liquid or gas which would be conducted to a central station to power electric turbines.

Solar energy produced in sunlight hours must be stored, however, for use at night and on cloudy days. While competitive, cost-effective means of using solar power to produce electricity on a large scale may be developed, solar energy concepts and technology for space heating and cooling are well established.

Passive Solar heating systems for homes and other buildings use an architectural design to provide modest solar assistance. Windows are placed to admit the maximum amount of sunlight in winter. Massive brick or tile floor and wall surfaces absorb the sun's heat during the day and radiate the heat at night. Trees and shrubs can be planted to shade the house in the summer and provide wind protection in the winter.

Active Solar heating systems use tubes attached to black, flat-plate collector panels that absorb the sun's heat. Another type attains higher fluid temperatures by focusing the sun's rays on the tubing. The heat is transmitted to water circulating through the tubing. Fluids may be pumped to an insulated storage tank and then to heat exchangers which warm the rooms with hot water or air. Another active system collects heated air and moves it through ducts. Part of the heat is stored for release at night or in cloudy weather. Large spaces are required for the water, rock, or chemical storage systems being tested. The storage tank or bin is generally designed with a capacity to provide heat for at least three days in cloudy weather. Conventional heating systems are usually needed in many parts of the country for backup.

The most practical and cost effective use of solar energy is for heating water. These units are relatively simple and have been used in some parts of the country for many years.

The attractions of solar energy include cleanliness and availability, as well as freedom from manipulation by foreign producers. The sun's radiation falling on less than 0.5 percent of the U.S. could supply our total electric power needs if efficient conversion equipment were developed. The problem lies in developing technology to use this energy source efficiently.

Wind Energy is produced as sunlight warms the air differentially and varies air movement. Wind power can be harnessed by propellers connected to electric generators. However, wind is intermittent, diffuse, and variable in intensity. Although not affected by clouds and darkness as solar power is, wind is undependable, so additional costs are necessary for batteries or some other means of energy storage. Wind system technology is well developed, but cost reductions are needed for economic power generation.

People relied on wind for centuries to sail ships and propel windmills. Wind power may again become a supplemental energy source where large propeller-driven generators can be used by smaller utilities, rural homes and farms, and for pumped water storage.

Ocean Energy can be obtained from waves, tides, currents, and ocean temperature variations. The ocean is the world's largest solar collector, absorbing nearly 75 percent of the solar energy that strikes the earth. Ocean waves and currents produce water movement which could be mechanically converted into hydraulic pressure to drive turbine-electric generators. Only small, experimental models have been built to test these energy sources.

Tides represent a renewable energy source caused by the gravitational force of the moon. In a tidal power plant, a reservoir is filled at high tide and emptied at low tide. Power is generated both when water enters and leaves the reservoir. In a restricted area, where the tidal height is sufficient to justify construction, a dam could control the twice-daily flow of water into a narrow ocean bay or coastal inlet. There are, however, very few locations where such a plant could be built near areas of high electricity demand. Additionally, capital and operating costs for such a facility would be two to four times higher than those of a fossil fuel plant with similar capacity. Two major tidal projects are in operation, one in France and the other in Russia. The French facility uses 30- to 40-foot tides for generating electric power.

Ocean Thermal Energy Conversion (OTEC) uses the temperature difference, as much as 45 degrees, between warm surface ocean water and cold, deep water to generate electric power. In certain tropical locations, a typical OTEC power plant could use sun-heated, surface water continuously drawn into a heat exchanger to vaporize a fluid that boils at low temperature, such as ammonia, propane, or Freon. The pressurized vapor would be used to drive a heat engine connected to a turboelectric generator. Cold, 40-degree F water, pumped from 2,000-foot depths, would condense the vapor into a liquid and the cycle would be repeated. The efficiency of an ocean thermocline plant is only 3 percent. This inefficiency is offset by a dependable source of safe, clean, renewable energy that would provide electricity on a 24-hour basis.

Current problems with OTEC plants include high initial installation costs, fouling by marine organisms, corrosion of metal components by sea water, and inefficiencies of long, underwater transmission lines to population or industrial centers. Transmission costs could be overcome by building huge seaborne platforms with floating factories to make hydrogen for fuel, extract minerals and chemicals from the ocean, refine aluminum, or to produce nitrogen for fertilizer.

Bioconversion includes all organic matter — biomass — that can be used for or converted to a more usable form of fuel. Biomass encompasses marine and terrestrial plants, wood, agricultural and forestry residues, municipal sewage, and organic waste. These materials can be burned to heat buildings or produce steam for electricity generation, hydrogenated through thermochemical conversion to make oil or gas, fermented and distilled to produce alcohol, or decomposed by anaerobic bacterial digestion to produce methane gas. Biomass is replenishable. In addition to trees, selected crops such as marine kelp or hyacinth can be grown for quick harvesting and maximum fuel yield. Crop, food, industrial waste, animal residues, and urban sewage can be turned into fuel by hydrogenation, pyrolysis, and distillation.

Resource Recovery. We generate about one ton of waste per person each year, which must be transported and disposed of in some manner. Sorting waste is expensive but metals such as copper, tin, and iron could be reclaimed and recycled. As an example, a recycled pound of aluminum uses only 5 percent of the energy required to produce it from bauxite ore, and pound for pound, paper in trash contains as much energy as high-grade coal. Therefore, a portion of the handling and processing cost could be charged to normal disposal costs. However, to date, no bioconversion system is economically competitive with conventional fuel, and even the conversion of agricultural crops remains an exciting, if economically unproved, alternative to fossil fuels.

Geothermal Power is obtained from super-heated water or steam, produced when underground water comes into contact with rock heated deep within the earth's interior. This vast heat reservoir, constantly radiating from the earth's core, sometimes concentrates in geothermal hot spots that can be tapped by drilling wells. Natural steam, reaching 700 degrees F or more, can be removed from the porous rock reservoirs, processed to remove impurities and corrosive materials, and directed to turbine generators to produce electricity.

Although about 14 states have some geothermal resource potential, most sites are located in the western United States, and are limited to about 90 locations in California, Idaho, Nevada, and Oregon. For example, "The Geysers" installation in northern California produces enough electricity for a community of half a million homes. In other locations, some homes are heated from local hot subsurface water. Iceland, Italy, and New Zealand use geothermal energy to heat buildings and generate some of their electricity requirements.

There are problems to be overcome before geothermal resources are commercially viable. The reservoirs are often difficult to find. High levels of impurities are often encountered and must be removed and disposed of in an environmentally accepted manner, and equipment must be developed to withstand the corrosive chemicals encountered.

Nuclear Fusion may someday provide practically unlimited amounts of electricity if complex technical problems are solved. It promises virtually limitless energy, but poses perhaps the greatest technological challenge ever faced by scientists. Fusion derives energy by combining the nuclei of two light atoms into one; just the opposite of fission, which splits the nucleus of a heavy atom to generate power.

Experiments are being conducted to develop safe, efficient fusion reactors—atomic furnaces—using lasers to heat ionized gases called plasma to more than 100 million degrees F. No known materials can withstand the tremendous temperatures required to induce and maintain a fusion reaction. The reacting particles must be suspended and compressed by magnetic confinement in a vacuum, free of any matter that could conduct the heat away from the reaction.

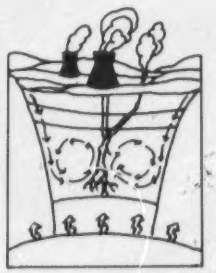
A prime advantage of thermo-nuclear fusion is the fact that it uses fuels which are virtually inexhaustible. Low molecular weight deuterium and tritium, isotopes of hydrogen, are both found in sea water. One gallon of ocean water contains enough of these isotopes to equal the energy value of 300 gallons of gasoline. Tritium can be created by bombarding lithium with neutrons in a nuclear reactor.

When the energized nuclei of these atoms collide with enough force, the fused isotopes react to form helium. The loss of mass releases tremendous quantities of energy, and the heat generated would be used to power steam-turbine electric generators. Once the nuclear fusion reaction begins, the hot plasma would supply its own heat for burning newly injected fuel.

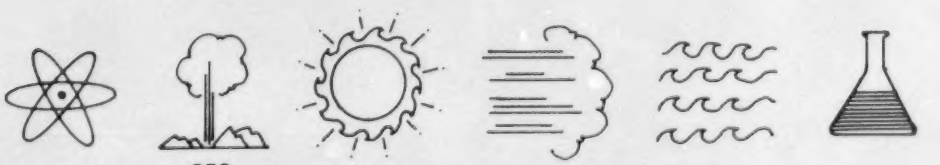
Fusion technology is in the experimental stage and no early solutions are expected. When the challenge of containment is overcome, the problem of commercial development would become economics. The construction and operation of a fusion reactor must be competitive with all other sources of energy available at the time.

The advantages of fusion power include: availability of inexpensive and abundant fuel, no chemical pollution, low radioactivity with no radioactive waste products from the expended fuel, no runaway reaction possibility, site flexibility, and thermal efficiency comparable to conventional steam-generated power plants.

Other Alternative Sources may be of interest to your students. They could research and write about such innovations as magnetohydrodynamics (MHD), thermonics, thermoelectricity, electrolysis, and various processes using hydrogen combustion. Also review the possible ways of securing energy from established fuels, coal gasification and liquefaction, and extraction of oil from oil shale and tar sands. However, recovery from any possible optional energy resource will require substantial investment in time, technology, and money.



Geothermal energy from deep in the earth's crust can be tapped to generate steam power in some selected areas.



NUCLEAR	GEO-THERMAL	SOLAR	WIND	TIDAL	BIOMASS
Electricity	Electricity and Heating	Electricity and Heating	Electricity	Electricity	Electricity and Heating

Since many of the alternative energy sources produce electricity, methods of storing electrical energy are important. They include charging batteries, compressing air, pumping water to a higher reservoir, or electrolyzing water into hydrogen and oxygen for use as a fuel.

Ecology, Environment, and Economics are concerns because energy extraction and processing may result in environmental problems and the need for land reclamation. Some fuels may also need various degrees of emission or waste disposal control. Costs for such processes are, of course, passed on to the consumer. Energy companies and industry are striving to achieve the economic balance needed both to supply sufficient energy to sustain our lifestyle and to maintain a clean environment. In the final analysis, society itself will decide how much new energy technologies are worth. The ultimate choice among competing fuels will depend on their overall cost to the consumer per unit of energy purchased.

ADDITIONAL ACTIVITIES

1. Introduce your class to the concept of "lead time" involved between the development stage and commercial application of new energy technologies. The following are estimated lead times normally experienced in securing licenses, approvals, environmental and archaeological site surveys, permits, hearings, exploration, and development of all the other industrial facilities and support equipment needed to bring some of these energy sources to customers at a price they can afford.

Typical Energy-Related Time Factors	Years
Building specialized mining equipment	5-8
Developing an underground coal mine	8-10
Development of an open pit mine	10-15
Approval, design, and construction of a nuclear power plant	10-15
Developing practical shale oil production	8-10
Developing geothermal production	7-10
Developing economical solar voltaic cell	10-40
Developing commercial fusion power	25-50

2. Have each student select one energy alternative technology to report on. He or she can research where it comes from, determine how it functions, its production economics, delivered cost, environmental effect, its advantages and disadvantages, and problems or opportunities of each source.

In studying environmental effects, students will explore how the energy source can be produced and used without disturbing the delicate balances of nature. They will find that discovering, extracting, processing, and using most forms of energy can lead to environmental problems. Solving these problems or providing equipment or processes to alleviate water, air, and thermal pollution costs money, which ultimately must be paid for by the energy user. They will realize that at some point a trade-off must be considered regarding the amount of pollution to be removed versus the cost of the energy being purchased by the consumer.

Because of rapid developments in alternative energy sources, students should consult the **Reader's Guide to Periodical Literature** for the most current information.

3. Energy futures: Between now and the year 2000, the United States will consume more energy than in its entire history. By 2000, U.S. demand for energy in all forms is expected to double, and worldwide demand may triple. Where will these new energy supplies come from? Teenagers are always interested in their futures. Most expect to have many material possessions and energy-consuming devices, even though many have not considered the significance of energy consumption trends, where future energy supplies will come from, or the energy used to produce materials that cannot be reclaimed or recycled.

   Encourage students to think about their future lifestyles: What will they be doing in the year 2000 or 2010? What will their life be like? Where will they live or work, and how will they get there? Will they work at home? How will they communicate? Will they have a family? What size? Where will they vacation? How will their lifestyle be affected by an increase or decrease in available energy? Now ask them to predict the energy future. Will there be more, less, different forms of energy? In what ways will these energy forms be adapted to their needs? Will energy in general be more or less expensive? Why?

   Have them compare their prediction for their future lifestyles with the energy supplies they anticipate. Are the predictions consistent? Do they look forward to a better life or a life with restrictions?

4. Energy demonstrations: You can demonstrate that the theory behind each additional energy source has a practical application.

a. Wind power: Use a homemade or toy pinwheel, or two electric fans. Blowing on the pinwheel will make it revolve. If an adjustable-speed electric fan is turned on facing another fan not plugged in, the blades of the second fan will revolve like a turbine. As the speed of the fan is increased, the blade rotation of the second fan will also increase and give a visible demonstration of the amount of wind energy being applied to turn the blades of the second fan.

b. Bioconversion can be demonstrated by burning some bread scraps in a heat-resistant beaker. Place a heat-resistant funnel over the top of the beaker and hold the pinwheel over the funnel. The rising heat will cause the wheel to spin. The char remaining in the beaker is probably a form of carbon which could be treated in a commercial facility with hydrogen to produce a form of oil.

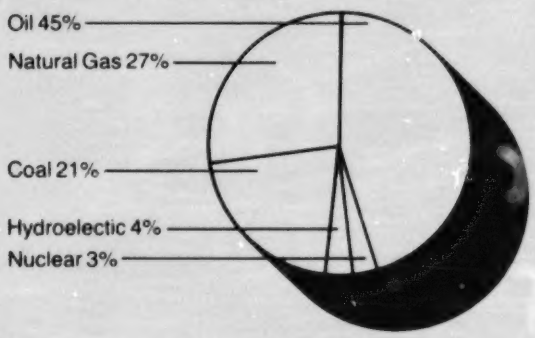
c. Solar: Use a magnifying glass to ignite paper or make a piece of wood smolder. This quickly shows how concentrated sunlight produces an intense heat. Now focus the sunlight with the magnifying glass on about one-half inch of water in a test tube. How long does it take to heat up?

d. Geothermal: Heat some water in a whistling tea pot. When the water reaches the boiling point, the pressure pushes the steam against the inside of the pot and it begins to escape through the whistle. Hold the pinwheel over the spout and the steam pressure will make it turn.

ACTIVITY 7

Energy Conservation–Town Meeting

U.S. Use of Primary Energy Sources



STUDENT OBJECTIVES

As a result of completing this activity, students should be able to:

1. Give several reasons why some conservation efforts are successful.
2. Explain the significance of conservation in relation to energy use.
3. Mention ways consumers can conserve energy and save money.
4. Understand some of the ways energy can be saved in each of the four sectors of society — industrial, transportation, commercial and residential.

BACKGROUND AND TEACHING SUGGESTIONS

Energy conservation is the wise use of energy, resulting from a rational response to price changes or a shift to the most efficient transportation, heating equipment, and manufacturing processes using the lowest cost, most available fuel resources.

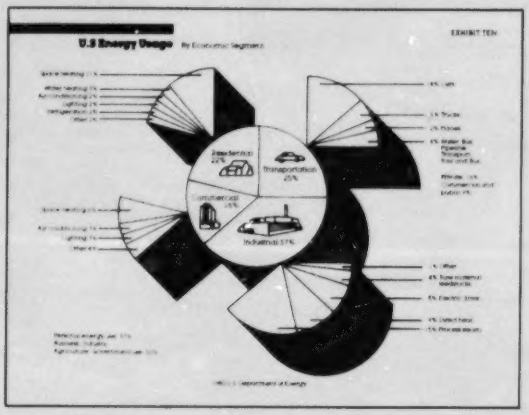
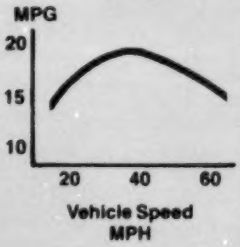


Exhibit 10, U.S. Energy Usage, illustrates energy consumption among various user categories and provides information for the classroom activities that follow.

Industrial. The industrial sector, which includes all mining and manufacturing, consumes more than a third of our nation's energy. Many companies have achieved substantial reductions in energy consumption since 1974. Industry's approach involves heat recovery, co-generation, heat loss control, equipment adjustment, materials recycling, and energy management. Following these initial efforts, most major industries apply energy conservation analysis, research, and the application of new technologies toward finding energy conservation solutions. Employment levels, productivity, public health and safety, and environmental factors are all considered in arriving at answers.

Transportation. We use about one-fourth of our total energy moving people and freight. The transportation sector consumes 60 percent of our petroleum. The family car is the largest single energy-consuming device owned by most people. Our more than 120 million automobiles consume about 100 billion gallons of fuel each year. [That's enough gallon cans of gasoline to stretch more than 400 times around the globe.] Since more than half of all car trips are fewer than five miles, it seems that other means of transportation could often be used. It is estimated that for each 1 percent of urban passenger car miles replaced by public transportation or electric vehicles, some 525 million gallons of gasoline would be saved.

FUEL ECONOMY VS. VEHICLE SPEED



A world gas mileage record of 375 miles per gallon was obtained using a very light, stripped-down motor vehicle with high pressure tires, while moving at a speed of 12 mph. Although motorists won't be able to get this kind of mileage with their cars, they can reduce wasteful consumption by good driving habits, proper vehicle maintenance, improved vehicle efficiency, use of public transportation when possible, and planned trips resulting in a reduction of miles driven. For example, reducing the speed from 70 to 55 mph increases mileage about 20 percent.

Residential and Commercial sectors use another third of the total energy we expend. Space heating accounts for about half of this energy consumption with cooling using another 10 percent. It is obvious that the heating and cooling of buildings provide our greatest opportunity to save energy. Insulation, caulking, weatherstripping, double-glazing, proper thermostat settings, and heating and cooling system maintenance can reduce home energy costs significantly. Insulation alone will reduce heat loss from 20 to 50 percent, depending on the construction of the building.

Well-insulated water heater tank and piping, lower temperature settings, elimination of leaking faucets, and water conservation can also save energy, since hot water accounts for about 13 percent of residential energy consumption.

The following chart shows where heat transfer losses occur in buildings:

- as much as 40 percent through ceiling and roof
- as much as 30 pecent through exterior walls and floors
- as much as 20 percent through windows and doors
- as much as 10 percent through air leakage

Insulating a typical home costs from $300 to $500 and saves the equivalent of several barrels of oil a year. Oil or gas saved is as valuable as oil or gas pumped out of the ground.

Most students have already learned many ways of conserving energy but may not be practicing what they know. This activity reviews energy conservation in the larger context of the nation's energy use patterns and attempts to develop student interest in energy conservation and practices. When studying energy use by economic category, students can use social science procedures to examine problems and suggest conservation solutions.

If you prefer, a town meeting concept can be used in role playing. Divide the class into groups: Conservation Council members, business and industrial managers and owners, government and regulatory officials, and the concerned public.

Have each group develop questions for the Conservation Council experts to answer. Limit the Q and A session for each group to 10 minutes, followed by an open class discussion. Several class periods may be required to explore all aspects of energy conservation.

Project or duplicate Exhibit 10, U.S. Energy Usage, so the following information can be reviewed before students complete the activity sheet. There will often be several correct answers or interpretations to each question asked on the activity sheet.

Before you hold your town meeting, distribute the activity sheet. After students complete the first question, review their answers to be sure everyone understands the assignment. The purpose is to allow students to identify problems, analyze the benefits and detriments, and draw conclusions. Be prepared for some unexpected answers. Remind students that they should be able to defend their answers and explain the thought sequence that led to their conclusions. After students complete the exercise, review each question with the class. Encourage discussion of their different viewpoints and responses.

1. For example, in addition to the answer shown for question one, another response might include: Some communities encourage fuel savings through car and van pooling. Special highway express lanes are reserved for the exclusive use of commuter buses and automobiles with four or more passengers.

   Ask students about the car brand, style, and size they prefer. Why? If they had their choice, would they buy a small car with exceptional gas mileage or a larger, more comfortable car with lower gas mileage? Is good mileage an important consideration when buying a car? What car options do they consider essential? How do these options affect the gas mileage obtained?

   What about driving habits? Do students drive in the most fuel-efficient manner? Or do they enjoy quick getaways, fast acceleration, and squealing stops? Do most students walk to school, drive their own car, come by school bus or by public transportation? Why?

YOUR ENERGY DOLLAR

Here's where it all goes:

Auto Travel	35¢
Bus, Train, Air Travel	4¢
Home Heating/Cooling	40¢
Hot Water	9¢
Appliance/Lighting	12¢

It is important that students realize their driving decisions have economic consequences, both on their own wallets and on the amount of fuel used. How do other people make car buying and driving decisions? (See Additional Activity 6 on page 28.)

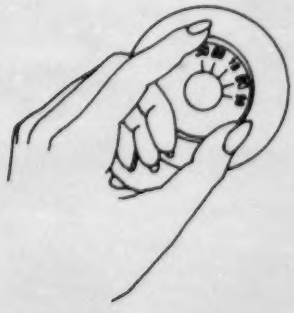
2. Conservation should be part of every individual, corporate, and national energy program. Conservation reduces our dependence on costly, unreliable foreign petroleum supplies. But since we are currently dependent on petroleum for about three-quarters of our energy, oil and gas will continue to provide the majority of our energy needs well into the next century. We must conserve by reducing non-essential uses of petroleum by encouraging thrift, and discouraging waste. That doesn't mean a reduction in economic growth, employment, or essential transportation. It does mean that the full cost of each form of energy must be recovered in the marketplace. That, in turn, will require each of us to use energy wisely, and to conserve in order to get maximum use of every energy dollar.

   Conservation alone cannot solve our long-term energy problem. While we are conserving non-renewable fossil fuels, we must seek out and produce additional petroleum supplies as well as pursue research and development of acceptable renewable optional energy sources.

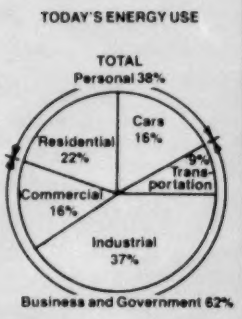
3. Conservation is working and should continue to be more important as Americans realize that real savings can be secured if they take action to reduce personal energy demand and related energy costs. Prices serve to balance energy supplies with consumer demands. About a third of our total energy consumption is used by individuals — 21 percent in the home and 13 percent for transportation. Individuals have a real opportunity to make major reductions in energy demand.

4. A world map will show the comparative sizes of the U.S. and European countries. Students will understand that mass transit systems are most useful in the parts of our country that have concentrated population densities similar to many European areas.

   Students can research what other countries have done to reduce oil imports.How do foreign governments control or stimulate consumer conservation in the areas of transportation, housing, industry, and agriculture? Do they encourage mass transit with relatively low subsidized fares? What effect do oil imports have on their economy? How are they paid for? What taxes are imposed to reduce energy demand? Is energy regulation productive?



   Why is mass transit more energy-efficient than the private car? On the average, cars carry less than two people — and usually only one. Yet they use most of the gasoline consumed in transportation. The extra energy needed to move numerous one-occupant cars could be put to more efficient use with car or van pools. Buses and commuter trains are even more energy-efficient because they carry many more passengers at a lower cost per person per mile traveled. An automobile carrying one person at 55 mph uses about 10,260 Btu per mile. A ten-car commuter train carrying 1,600 passengers at the same speed uses 1,026,000 Btu per mile or 641 Btu per person. During rush hours buses are 15 times more efficient than cars, and commuter rail systems are even more efficient. Have students discuss the advantages and disadvantages of public versus private transportation. Which have the best potential for conserving gasoline and diesel fuel? How would students go about developing more mass transit and car pools, and then increase their use?



5. Several methods of government regulation have been considered to reduce foreign oil imports. A high tax could be imposed on imported crude oil. Additional excise taxes could raise the cost of gasoline and other motor fuels. Since most European countries have little or no domestic petroleum production, they must import a much higher percentage of crude oil than the U.S. Because of this, Europeans pay much higher motor fuel taxes in an effort to reduce imports.

   Rationing is another government option, but few students know the problems it presents. Put a chart on the chalkboard headed **Motor Fuel Rationing — Advantages and Disadvantages** to determine student knowledge in this area. Have them list the advantages and disadvantages they can think of. Try not to prompt answers until students have exhausted their list. If students are having trouble, delay the discussion and ask them to talk to people who remember gasoline rationing during World War II.

   Students can research the gasoline rationing system used during World War II. How did it work? Was the system fair? What problems were encountered? How were essential workers like doctors, nurses, and war materials factory workers allocated supplies? What about people who used their car daily in their work? Would people be more or less likely to accept rationing now than in wartime — even if there were a severe motor fuel shortage?

   The issue concerning government controls versus market forces is laden with judgmental values. Allow students to develop their own answers. If one point of view seems to be dominating, encourage new options by suggesting that students look at the problem from a different perspective. Stress that the issue is complicated and that it will need their best thinking in the years ahead.

ADDITIONAL ACTIVITIES

1. Have your class develop an energy conservation survey questionnaire to ascertain the concerns and opinions of others. They can distribute the survey to the student body or have it printed in the school newspaper. Ask for specific return date and publish the consolidated results. This activity could lead to a series of short essays written and published by students about energy conservation.

2. Volunteers can research and develop a skit for presentation to the class centering around the "good old days." Two students can play the roles of grandparents and another boy and girl can discuss how today's energy situation influences their lifestyle. The grandparents can maintain that the quality of life was better when they were teenagers because life was simpler then, or they can explain that life is much better today because energy has been used to make life better. Either way, the discussion should be fast paced and exciting because the premises deal with people's most basic values.

3. Students may not be aware of the relative energy efficiencies of some items or the percentage of energy converted into useful (heat or motion) work. The following table of energy efficiencies provides information on which to base additional discussion:

Gas Furnace	85%	Gasoline Engine	28%
Oil Furnace	70%	Steam Locomotive	8%
Electric Water Heater	79%	Diesel Locomotive	35%
Gas Water Heater	46%	Incandescent Lamp	4%
Large Electric Motor	95%	Fluorescent Lamp	12%

   What causes each to be more or less efficient? Why are some items preferred or in more demand even though they are less efficient? How does the initial cost of some items compare with others? For example, although most fluorescent tubes cost more than incandescent bulbs, they produce more light for about one-fifth of the price, and can reduce lighting costs by 80 percent. Fluorescent lamps produce three to four times as much light for the same energy and last 10 to 15 times longer. One 40-watt fluorescent provides as much light as one 150-watt incandescent bulb or eight 25-watt bulbs.

4. Have students prepare a list of electric, gas, and gasoline powered appliances used in and around the home. Each student or team should select an appliance or appliance group and compile material about the item(s) including:

   - How do advertising and marketing strategies affect consumer decisions to buy an appliance?
   - Collect advertisements about similar appliances. What advertising claims are made? What is unique about one item versus another?
   - Secure energy-efficiency rating, useful life expectancy, care and maintenance instructions, warranties, and other information affecting buying decisions.
   - Review or calculate the energy cost of operating a specific appliance.
   - Determine, when possible, the amount of energy required to manufacture the appliance.
   - Is the appliance needed in the family lifestyle?
   - Is there an energy conserving substitute for the appliance?
   - Is the appliance a status item? Why?

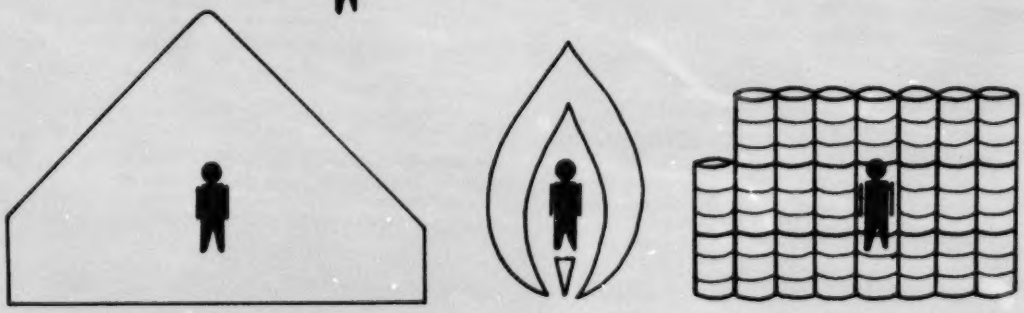
5. U.S. Department of Energy estimates that an average person living in the suburbs of a large city uses 45 percent more energy than the city dweller because 1) cars are not as efficient as mass transit; 2) city apartments are generally smaller and often easier to heat and cool than larger suburban homes; and 3) shopping, recreational facilities, schools, and work are more centrally located in the city. Have students make other energy use comparisons between city, suburban, and rural communities including the public services required.

6. Students will become aware of the need to conserve gasoline if they develop a transportation profile of their class.
   Include:

   Number of cars driven by students each week.
   Number of miles driven per week.
   Number of passengers carried.
   Average miles per gallon used.
   Average cost per person carried.

   What better or alternate transportation methods would they recommend?

ANNUAL PER CAPITA ENERGY CONSUMPTION IN THE U.S.



Coal
3.1 Tons

Gas
91,250 Cu. Ft.

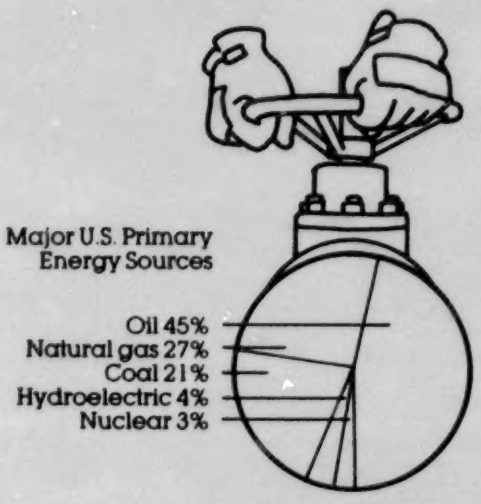
Oil
1168 Gallons

Energy The Great Adventure

What is your energy I. Q.?

	True	Not Sure	False
1. We use more petroleum than any other energy resource. Most oil is used to power transportation vehicles, and automobiles are the largest single user of petroleum products. The U.S. accounts for nearly 14% of total world production but consumes about 33% of the world's oil. Cars use 90% of the refined products.	X		
2. Solar power is low cost because sunlight is free. Solar voltaic cells that convert sunlight to electricity and central solar power generation equipment are limited until their application becomes more efficient and less expensive, but the energy source is inexhaustible.			X
3. Natural gas, which supplies about one quarter of our energy, is mainly used to heat our homes and buildings.	X		
4. Coal was the most important energy source that fueled America's industrial development during the hundred years after 1850. Coal currently supplies 19% of our energy but in 1900 it supplied about 70%.	X		
5. Finding oil is a risky and expensive business but geologists are always sure petroleum will be found when they recommend a drilling site. Only about one well in fifty results in a significant commercial find.			X
6. Electricity is called a secondary form of energy because it is made from other energy sources. All electric generators are powered by some other primary energy source.	X		
7. Natural gas and petroleum products are difficult to transport by pipeline. Our extensive gas and oil pipeline system permits efficient transportation of all forms of petroleum.			X
8. Because of environmental problems, coal is rapidly becoming an unimportant energy resource. As petroleum fuels become scarce, increasing amounts of coal will be used in an environmentally acceptable manner.			X
9. Falling water and nuclear fuel are used to generate most of our electricity. Hydroelectric plants produce 13% and nuclear power plants 11%. The balance is generated by fossil fuels.			X
10. Many wells that formerly produced crude oil are now closed down and probably contain no more petroleum. Oil companies are using advanced recovering methods to produce more oil from wells once abandoned as unprofitable.			X
11. Coal can be converted into cleaner burning gases and liquid fuels. Complicated, expensive processes which add hydrogen to coal are being tested to produce gases and liquid hydrocarbon fuels.	X		
12. There is probably a lot of natural gas and crude oil still to be found in the United States. Very few federal land and offshore locations have been explored for petroleum.	X		
13. The nation's use of nuclear energy is increasing rapidly with few problems or restrictions. Many safety regulations and environmental problems have increased costs and slowed nuclear energy development.			X
14. Geothermal energy, a form of solar energy, is generated daily by sunlight. It results from water being heated deep inside the earth.			X
15. Because part of an offshore well goes through water, it costs less to drill than one on land. Offshore wells cost as much as ten times more to drill than wells on land.			X
16. Natural gas is often found in association with crude oil. About 30% of the wells produce both oil and natural gas.	X		
17. Most of our electric generating plants are fueled with coal. Coal is used to generate about half of our electricity.	X		
18. Fission means splitting the nuclei of atoms to produce heat energy from a nuclear chain reaction.	X		
19. Garbage and organic refuse can be converted to produce heat or electric energy. Some cities are using processed garbage as a fuel to generate electricity or to produce methane gas.	X		
20. Most energy researchers expect a technological discovery within 20 years that will solve our energy problems quickly and economically. A breakthrough is possible, but most energy experts think it unlikely.			X
21. As energy becomes more expensive, conservation is the best way to lower fuel costs. Conservation helps us use scarce energy supplies more efficiently.	X		

Petroleum
From Fossil To Flame



Read each description and fill in the preceding blank with a word from the list below. Then indicate the order in which these steps occur by writing the appropriate number inside the box by each description. Note: Two boxes are provided for transportation.

EXPLORATION
REFINING
TRANSPORTATION
DRILLING
MARKETING
PRODUCTION
LEASING

4 PRODUCTION

Only about one-third of the crude oil in a typical oil-bearing formation flows naturally so that it can be pumped out. The remainder is trapped in porous rock. Oil companies use a variety of secondary recovery techniques—water, chemical and gas injection, and combustion—within the formation to help the oil flow to the wellhead. As oil becomes increasingly scarce, oil companies rely more and more on these expensive secondary recovery techniques.

3 DRILLING

Determining if a likely geological formation contains oil is the most costly industrial activity in America. On the average, only one "wildcat" well out of every six drilled produces oil or natural gas in commercial quantities. The cost of finding oil ranges from an average of $200,000, for a well on land, to more than $2 million, for offshore marine wells.

2 EXPLORATION

Petroleum geologists are trained to recognize structural features of surface formations that might indicate the presence of oil or gas. By measuring gravity and magnetism, and by the use of seismic sound waves to measure underground echoes, geophysicists gather information about underground formations. Then the only way to find if petroleum is present is to drill a well.

6 REFINING

The first step in processing crude oil is distillation. The crude oil is heated and piped under pressure to a huge—15 to 20 story—fractionating tower. As the hot vapors rise, different hydrocarbons condense at different levels. Gases and gasoline condense near the top; farther down the tower, jet fuel and kerosine are removed; next, diesel fuel and heating oils; and finally, near the bottom, lubricants, heavy oils, asphalts, and other residual products. The products require extensive additional processing and treatment. Today almost twice as much gasoline is obtained from each barrel of crude oil as in 1920.

1 LEASING

The land agent acquires property to drill on. Oil companies purchase the right to explore, drill for and produce any oil and natural gas found under the land. Usually the landowner continues to use the surface as he pleases. The landowner may receive a bonus when arrangements are completed as well as an annual rental fee for each acre. In addition, landowners receive royalty payments for any oil and gas produced.

8 MARKETING

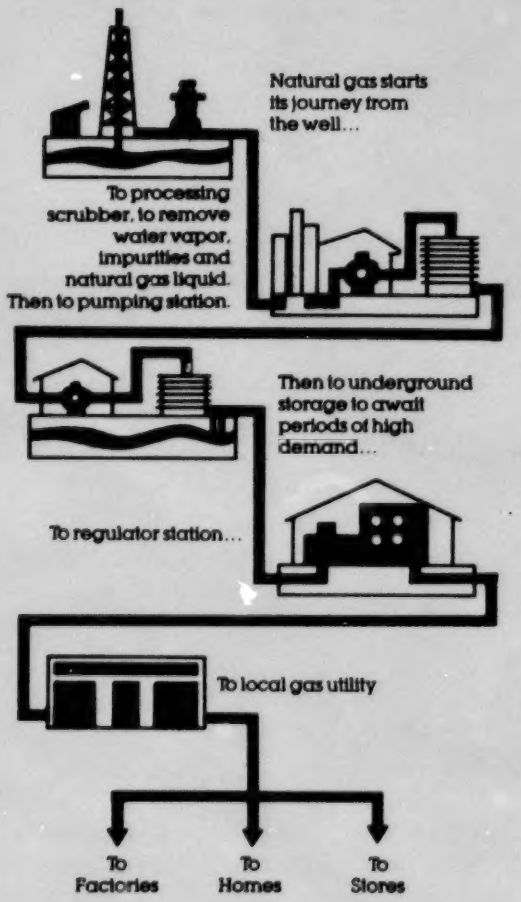
Many of the more than 2,000 products produced from petroleum—the synthetic fabrics and plastics sold in every department store—are made from less than five percent of the crude oil. But nearly half of every barrel of oil refined becomes gasoline. Some 200 plus U.S. refineries and approximately 12,000 distributors sell gasoline to service station dealers. Eight out of 10 service stations are owned or operated by local independent business people.

5 **7** TRANSPORTATION

Almost 60 percent of all crude oil produced and refined in the U.S. is moved efficiently through more than 227,000 miles of pipeline. Ships and barges transport another 35 percent via coastal and inland waterways. Trucks carry three percent, mostly refined products, generally over relatively short distances. Less than two percent of the petroleum is transported by railroad tank cars.

Natural Gas
Clean Convenient Energy

How Natural Gas Comes To Our Community


Natural gas starts its journey from the well...
To processing scrubber, to remove water vapor, impurities and natural gas liquid. Then to pumping station.
Then to underground storage to await periods of high demand...
To regulator station...
To local gas utility
To Factories
To Homes
To Stores

A. Circle T for true, F for false

(T) F 1. Natural gas supplies about 25% of U.S. energy.

T (F) 2. Natural gas is another name for gasoline.

(T) F 3. Gas can be manufactured.

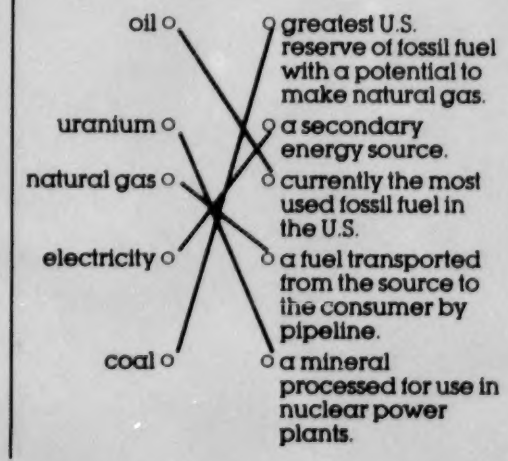
T (F) 4. All natural gas deposits in the U.S. have been found.

T (F) 5. Natural gas is always found when drilling for crude oil.

T (F) 6. Natural gas is a renewable energy source.

(T) F 7. There are more than one million miles of gas pipelines in the U.S.

B. Draw a line to match the word with its best description


oil
uranium
natural gas
electricity
coal
greatest U.S. reserve of fossil fuel with a potential to make natural gas.
a secondary energy source.
currently the most used fossil fuel in the U.S.
a fuel transported from the source to the consumer by pipeline.
a mineral processed for use in nuclear power plants.

C. Circle the best answer

1. One of the earliest energy sources used by humans was: A oil, (B) wind, C coal, D natural gas
2. An example of a nonrenewable energy source is: (A) natural gas, B tides, C the sun, D wind
3. Energy shortages are caused by all of the following except:
   A oil embargoes
   (B) development of new energy sources
   C government regulations
   D population growth
4. Future gas supplies may come from:
   A coal gasification
   B imported liquefied natural gas
   C biomass resource conversion
   (D) all of the above
5. The sources that provide most of our energy today are:
   A nuclear, geothermal, and biomass
   (B) coal, oil, and gas
   C wind, sun, and water
   D all of the above

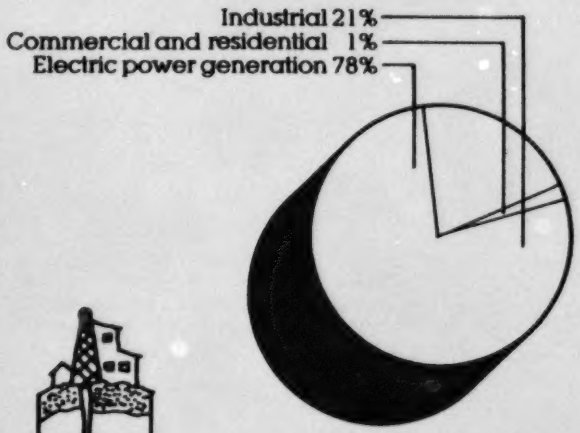
Fill in the blanks with the best answer.

6. Most natural gas comes from a group of organic chemical compounds called hydrocarbons
7. What forces that affect all moving things make it necessary to have pumping stations spaced along a pipeline? friction and gravity

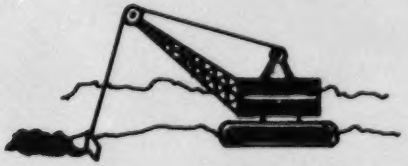
Consider Coal The Abundant Fossil Fuel

Coal Facts

How coal is used -- by economic sector



As an electric utility manager, you are interested in the new generating plant your company is building. You are considering coal to fuel the steam turbine generators. Read the coal facts. Then draw your conclusions from the facts presented and your previous discussions about coal.



ADVANTAGES Coal is our only abundant nonrenewable energy source. Technological improvements will enable us to mine and use coal more efficiently and convert it to cleaner hydrocarbon liquid and gas fuels. For every ton of coal consumed, an estimated four barrels of oil are saved.

ADDITIONAL COSTS The federal Clean Air Act requires all new coal burning plants to install expensive antipollution devices to remove sulfur and particulate emissions. The federal Coal Mine Health and Safety Act mandates extensive miner training and mine safety procedures.

SUPPLY The U.S. has economically recoverable coal reserves estimated to be in the 250 to 300 billion ton range. This is enough to last for 300 years at current levels of use, and accounts for 80 percent of U.S. fossil fuel reserves.

FEDERAL LANDS Many people feel that government policy should permit increased domestic coal production from federal lands, which hold 40 percent of our remaining coal reserves but now provide less than 10 percent of production.

MINING About 60 percent of the nation's coal is surface mined. This method recovers 80 percent of the coal. Deep-mined coal costs almost twice as much as surface-mined coal and leaves up to half the coal underground.

PROCESSING Coal is crushed, cleaned, and sorted according to grade and purity.

TRANSPORTATION About two-thirds of the coal mined in the U.S. is transported by train. One unit train, consisting of 100 to 120 hopper cars, can carry 10,000 to 15,000 tons of coal per trip. Trucks carry about 13 percent of our coal and barges and other vessels move 10 percent. Electric power generation consumes most of the rest near the mine site.

ENVIRONMENTAL CHALLENGES Coal burning plants need to develop environmentally satisfactory ways to reuse and purify the processing water; to install efficient air control antipollution devices; and to dispose of solid wastes.

Answer the following questions:

1. Your other generating plant burned oil. What made you decide to change to coal?
   The new plant will probably burn coal because it is readily available, and in most areas it is less expensive than oil.

2. Most of the coal burned will be surface-mined. Who will pay to fix up the land after the coal is removed?
   Although the coal company will pay the direct cost, the added production expense will ultimately be passed on to the consumer of the electricity in the form of higher electric bills.

3. Are you more interested in locating your plant near a navigable river or major rail line?
   Although water transportation is slower and often less expensive than rail, most executives in northern areas would probably want to locate near rail lines to prevent delays when rivers are frozen.

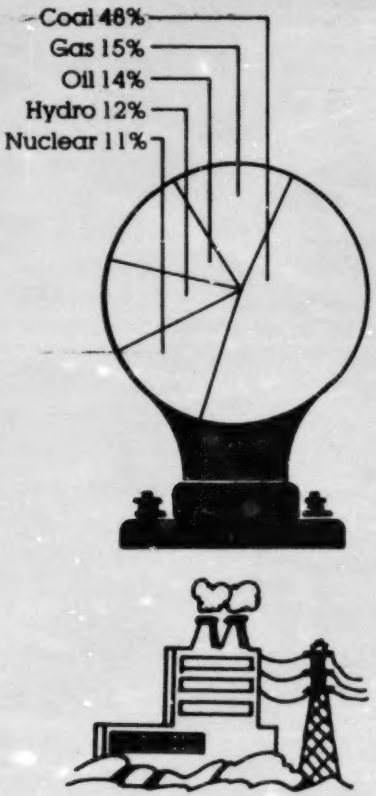
4. You will be burning high-sulfur bituminous coal. How will it affect the cost of electricity generated at your plant?
   High-sulfur coal requires more antipollution control devices at the generating plant. The cost of this equipment must be recovered in the cost of the electricity sold.

5. There is a large tract of unused federal land with coal deposits close to your plant. Would you favor developing new coal production from that area? Why?
   If coal could be mined and the land reclaimed at this nearby tract, there would be lower transportation costs.

6. The use of coal for commercial and residential heating dropped from 60 percent in 1930 to only 1 percent in 1980. Why?
   Heating oil and natural gas were cleaner and more convenient.

Electricity
Our Versatile Energy Servant

Primary Sources of Electric Energy: What We Use To Make It



1. What is an electric current? electrons in motion

2. Why is electricity considered a secondary source of energy? Because it must be made from a primary energy source such as coal, oil, uranium, or the power of falling water.

3. A utility company can choose from several energy sources to make electricity. Why might a utility choose each source listed?

Coal	Abundant nearby supply; generally less expensive to use than oil or gas.
Petroleum (oil or gas)	Less pollution than coal; could be close to a relatively low-cost supply and far from coal supplies.
Nuclear power	Less pollution; may be located far from fossil fuel supplies.
Hydro power	Available supply of falling water.

4. What happens when energy is converted or changed from one form into another? Some of the original energy is changed into other less usable forms of energy. When we use energy we do not destroy it. We only change it into other forms.

5. We know that the United States has an abundant supply of coal. If that is true, why does coal supply less than half of our electricity? The coal may be located far from the area where the electricity is needed and transportation costs would make coal noncompetitive with some other means of generating electricity. In some areas it is more advantageous to use another fuel because of the expensive pollution equipment required for coal burning power plants.

6. Hydroelectric power seems the ideal energy source—it is clean, efficient, usually reliable—yet projections call for only small increases in hydroelectric generation. How do you explain this? There are a limited number of locations where dams can be built to harness water power.

7. Nuclear power is associated with fission reactors, breeder reactors, and fusion power. Which process is associated with most of the nuclear power plants now in use? fission

8. Electricity is converted to other forms of energy in your home, for example, the light that illuminates your room. What other forms of energy is electricity converted to? **Heat**—from resistor wires—toasters, irons, electric furnaces

Motion—from motors or relays—washers, sweepers, fans

Sound–from a telephone, radio, or phonograph

9. Name three factors that could affect the demand for electricity, that is, increase or decrease its use. Population increase or decrease, conservation, more efficient electrical devices, cost of electricity.

10. What is the primary energy source your local utility uses to generate electricity. Why was this source chosen? Answers will vary according to locality.

Our Energy Future
Alternative Sources

As we approach the 21st century, new energy sources other than the traditional fossil fuels—coal, oil, and natural gas—may play a larger role in providing America's energy needs.

SOLAR POWER is abundant, clean, and renewable, but it must be converted before it can be used as energy. Photovoltaic solar cells are one method of direct conversion from sunlight to electricity. Another method, thermal conversion, uses mirrors to focus solar heat on steam generators. At present, generating electricity by either method is more costly than the use of fossil fuels.

WIND ENERGY can drive propellers connected to electric generators. Relatively small battery systems can store sufficient power to serve the needs of a home or farm.

TIDAL POWER harnesses the rise and fall of tides by damming an ocean bay or estuary to control the flow of tidal waters, and uses the stored water to produce hydroelectric power.

OCEAN THERMAL ENERGY CONVERSION(OTEC) is a possible clean, safe source of electrical power. In certain tropical locations, sunwarmed surface water could vaporize a low boiling point liquid, creating a gas which would drive a generating turbine. The gas would then be condensed by cold water pumped from the ocean depths, and the cycle repeated.

BIOCONVERSION processes make organic matter into more usable forms of fuel. Biomass, which encompasses marine and terrestrial plants, wood, agricultural and forestry residue, municipal sewage, and organic waste, may be converted into a more convenient fuel by direct combustion, thermochemical, or biochemical methods.

GEOTHERMAL POWER is derived from hot water or steam produced when underground water comes in contact with rock heated by the earth's interior. In the western U.S., this heat may be tapped by drilling into local hot spots close to the surface where natural steam can be recovered and directed to power turbine electric generators.

NUCLEAR FUSION reactors—atomic furnaces—develop heat in the area of 100 million degrees F by the use of lasers and magnetic confinement. But complex technical problems must be solved before this more efficient source of nuclear energy is available.

Alternative Energy Sources Chart

INSTRUCTIONS: Based on the information provided and what you have previously learned, place a checkmark in each box in the chart that applies to the energy sources listed. Then write a paragraph on the back of this sheet discussing the alternative energy source you believe is best suited to provide our future energy needs. Give at least three reasons for your choice.

Alternative Energy Sources	SOLAR	WIND	TIDES	OTEC	BIOMASS	GEOTHERMAL	FUSION
ADVANTAGES							
Free or low-cost supply	X	X	X	X		X	
Replenishable abundant supply	X	X	X	X	X	X	X
Low operating cost	X	X	X			X	
Environmentally safe	X	X	X	X	X	X	X
Can be located where needed							X
Conserves land			X	X			X
Generates electricity	X	X	X	X	X	X	X
DISADVANTAGES							
High development or installation cost	X	X	X	X	X	X	X
Intermittent and variable	X	X	X				
Technology not competitive with fossil fuels	X	X	X	X	X	X	X
May pollute air or water					X	X	
Geographically restricted	X	X	X	X	X	X	
Waste disposal problem					X	X	
Generally high initial plant or production costs	X	X	X	X	X	X	X

Energy Conservation Town Meeting

You've been appointed Conservation Coordinator in your community. As the local expert, you're expected to answer all questions presented by citizens attending the town meeting. Remember what has been discussed. Then review the questions below that citizens of your community want answered. Using logic, answer each question to the best of your ability.

1. **Rose Ombud, president of a consumer group, wants to know what energy costs have to do with energy conservation. "How does cost affect the amount of energy people use?" she asks.**
   The more energy costs, the less people will use. The difference between what would have been used and what is actually used is conserved.

   Rose also wants to know if the federal government has done anything to require energy conservation, particularly in the automotive sector. Are there regulations in effect?
   The 55 mph speed limit, imposed in 1973, was designed to conserve motor fuel. Beginning in 1974, the automobile industry was required to engineer more fuel efficient cars. Changes in these mandates depend upon regulatory and legislative action.

2. **Noah Aspen, a member of the nature club, asks, "Why can't conservation solve our energy problem? If we save enough oil and natural gas, there should be enough for everybody."**
   There is a finite (limited) supply of these fuels. No matter how much we conserve, we must still use some petroleum until alternative energy resources are developed. The U.S. competes with the rest of the world for petroleum supplies.

3. **Jim Nitram, advice columnist in the *Daily Blather* asks, "How do I tell people about conserving energy in their home? Heating and cooling cost money."**
   Weather stripping, caulking, and storm windows and doors can reduce energy losses up to 15 percent; ceiling, wall, and floor insulation from 20 to 40 percent; and equipment maintenance and thermostat settings another 15 percent.

   "Obviously, it takes a lot of energy to provide the heat we need. Am I right in concluding that it takes a lot of electricity and gas to operate our home appliances, too?" Yes **"About how much?"** 6% **"What major appliances use the most energy, and how can we conserve the energy they use?"**

Hot water heater	Insulate tank and piping; reduce tempeature
Clothes dryer	Use full loads; hang clothes up to dry if possible
Air conditioner	Insulate, caulk, and weatherstrip—use storm windows and doors
	All appliances that heat up or cool down use large amounts of energy

   "How can we save up to half of the natural gas we use in our homes?"
   By replacing gas pilot lights in furnaces, stoves, water heaters, clothes dryers, and other gas appliances with automatic electric instantaneous ignition devices.

4. **Wally Streetman, rising young executive, asks, "We've heard about householders and motorists. Now tell me what has motivated business and industry to cut down on energy use?"**
   Business and industry managers look for all ways and means to reduce energy costs in order to supply goods and services customers can afford.

   "Why don't people conserve more energy in the residential sector of the economy? We have the means. Why don't people act?"
   Even with energy tax allowances, insulation, storm windows and doors, more efficient heating and cooling equipment are all expensive investments that take several years use before they become cost effective. People must have both the incentive and the means to put conservation into effect.

5. **Tess Traveler took a trip to Europe last year. "I saw lots of passenger trains and other kinds of mass transit. Why don't we develop more efficient transportation in the U.S.?"**
   European countries have experienced high energy costs for many years. Gasoline and diesel fuel are even more expensive there because of high taxes. European countries are smaller in area with the population concentrated in urban areas. People tend to live closer to their work.

6. **Barby Wheelcraft, a potential automobile buyer, observes, "How can market forces affect gasoline consumption?"** Higher gasoline prices affect driving habits. People drive less, maintain their cars better, buy smaller, more efficient cars, plan their trips, carpool, use more mass transit.

   "What government regulations would further limit gasoline use." Higher motor fuel taxes, rationing, alternate purchase days, limiting cars to one per family, limited times for fuel purchase, banning all recreational vehicles, taxing vehicles by horsepower and weight.

   "Do you think market forces or government controls are more effective in gasoline conservation? Why" (Use the back of paper for additional discussion.)

Energy and Economics

STUDENT OBJECTIVES

This activity should help students understand basic economic concepts that influence energy production and use. You may prefer to give students the Energy and Economics Quiz at the beginning of their energy studies. Do not grade this quiz. After discussing the answers, collect and file the quizzes. At the conclusion of this activity give students the Energy and Economics Quiz again. Have students correct their quizzes; then pass out the first quizzes and let them compare their scores.

BACKGROUND AND TEACHING SUGGESTIONS

A strong competitive free market system stimulates efficient production of energy and other goods and services. It encourages investment in research, more efficient machines, tools, equipment, and other capital goods necessary to improve productivity. The free market system benefits people; supplies resources to support social programs and improve the quality of life, and provides the taxes that pay for government.

An understanding of our economic system and how energy relates to our overall productivity and well-being will help us take a reasoned approach to controversial energy, ecology, and economic issues.

Economics deals with how people make the most effective use of productive resources to satisfy their needs. The primary purpose of the energy industry is to efficiently provide the goods and services people demand, and leave a profit for investors. A basic problem confronting people is that all resources are limited in relation to the demand for them. This basic economic condition requires people to make choices in supplying and consuming energy resources. This is the starting point for understanding the economic concepts that follow.

Economic Demands People's demands for energy are unlimited. Some energy demands satisfy fundamental needs to provide food, shelter, and clothing. Other energy, used for transportation or leisure purposes, furnishes convenience and the good living most people want. Other energy is consumed in protecting life and property.

Productive Resources Natural, human, and capital resources are used to produce energy and other goods and services. Energy companies combine these productive resources to explore for and produce various types of energy, process it into usable products, distribute, and sell it to customers.

Natural resources include land, minerals, water, air, and gases – the components of the products being manufactured. Many raw materials such as crude oil and natural gas are scarce and often hard to find and produce. Other resources, like crops and trees, can be replenished through people's work in replanting them.

Human resources are the physical labor and mental ability people use in work. Training, education, and organizational skills all help to increase labor productivity. Miners, engineers, geologists, chemists, managers, office people, computer programmers, accountants, and hundreds of people in a large variety of jobs develop their skills and abilities to make the energy industry function efficiently.

Capital resources refer to products people make to create other goods. These include mining equipment, drilling rigs, pipelines, processing plants, and all of the tools, machines, buildings, and equipment used to develop, produce, process, and distribute energy. Increased use of tools is a reflection of the technological, inventive, and scientific advances that knowledge and research bring. Skilled labor in combination with machines and tools powered by petroleum and electricity has been an important means of increasing productivity.

Productivity A higher standard of living results from increased productivity. Capital investment is a key to productivity, and savings are a major source of capital investment. People save when they forego buying a particular item now in order to buy something more desirable later. They will not save money and invest it for productive use if they are not rewarded for the risk and use of their money. People expect to be paid interest or dividends or have their investment increase in value.

Scarcity and Choices All productive resources are limited relative to our desires, and energy supplies are no exception. Because petroleum is scarce, people must continuously make choices among all energy resources. The relative prices of kinds of energy determine how much of each is produced; whether it is imported or exported; when, where, and how energy is produced; how many people are employed to provide and distribute the energy products; and how energy is used.

Opportunity Costs and Trade-Offs When people decide how to spend their money, they make a choice. As an example, they can choose from many different types of energy – oil, natural gas, coal, electricity, and other sources, such as wood, solar, and wind power. When they purchase one type of energy, they cannot buy other things with the same money. These trade-offs involve continuous comparisons of the costs and benefits of each energy alternative.

Economic Systems Groups of people organize economic systems consisting of the institutions, laws, activities, values, and motivations that govern their decision-making. In the free market, mutually beneficial exchange takes place among consumers and producers, workers and employers, and investors and savers. Consumers purchase goods and services, including energy. Producers supply and sell the goods and services demanded. Prices are determined from this voluntary exchange. If the government interferes with any of these market decisions – by directive, regulation, taxation, controls, subsidies, or any other means – the market signals are distorted, and the supply, and consequently the price, will be adversely affected.

Markets, Supply and Demand The market responds to all of the individual decisions made by people, businesses, and various government agencies. In the case of energy, this market mechanism matches the supply of various types of energy with the demands. This simultaneously determines the price of each type of energy and the amount that is bought and sold.

Without government interference, the supply of an energy product is determined by the amount producers are willing and able to provide at specific prices. Demand reflects the amounts of energy people are willing and able to buy at different prices during the same time period. The lower the price, the more will be demanded by users, and the higher the price the less will be demanded. Prices serve to balance the supply of energy with consumer demand.

Prices Market prices are the principal communication mechanism of our economy. Changes in prices provide the information people use in spending their money and affect how savings are invested. The free market price of a fuel reflects its relative scarcity and true value in the marketplace. Price allows us to make rational choices among the energy alternatives and environmental necessities.

Government intervention disrupts the communication mechanism. Without government regulation, sellers will compete with one another to find and produce more energy. The resulting prices would reflect the relative scarcity or abundance of the various forms of energy and determine who gets them.

Competition Business success attracts additional suppliers who compete for a share of the customers' dollars with the expectation of profits. Competition requires continuous exertion, innovation and improved products to respond quickly to people's demands.

Information Individuals act on the basis of their ideas, knowledge, and values. All consumers, workers, producers, investors, and employers use information about market conditions. Markets serve as a communication system for buyers and sellers. The better people are informed the better they can react to market changes.

Economic Incentives Consumers choose one kind of energy over another because the product they receive in exchange for their money better satisfies their demands. Energy producers, like other businesses, seek to optimize their profit by combining productive resources in the most efficient ways. Workers seek employment where they receive the highest wages consistent with the location and working conditions. Similarly, savers look for the best investment return for a given risk. Losses indicate changes must be made or that the resources should be used for some other purpose.

Profits In a free-market economy, the opportunity to earn a profit is the main reason for starting a business or increasing production. Profit is what remains after all the costs of production, distribution, and taxes have been deducted from the price that consumers are willing to pay. Thus, profit is both the incentive and reward for reducing costs, conserving resources, and finding better ways to satisfy customers. Only the successful make profits and even these businesses retain only a few pennies of profit from each dollar of sales.

A portion of profits is reinvested to buy the tools and equipment needed to increase productivity. Profits play a critical role in stimulating new investment for production, cost cutting technologies, research, and improved labor productivity through training and education.

Success, as measured by profits, creates additional competition as new business and sellers enter a growing market to gain an anticipated share of profits.

Specialization and the Division of Labor As people and business develop ways to conserve scarce energy resources, find more conventional fuels, and develop new energy sources, productive work is divided among workers to take advantage of their specialized skills or knowledge. This results in a division of labor. Efficiency and production are increased by specialization.

People in a free market economy have substantial freedom of opportunity. Because of inherent abilities, physical skills, education, and the willingness to relocate, people can – to varying degrees – take advantage of the work opportunities available in the marketplace as employers bid for their services. Worker availability for different occupations and their skill and educational achievements determine the wages received.

The right of individuals to make their own decisions is fundamental to our economic and political system.

Interdependence Interdependence is the relationship that exists among buyers, sellers, government agencies, and financial institutions within the total economic system. In private enterprise, people market their labor, savings, and property. Management coordinates productive resources to produce and sell consumer goods and services. These business producers pay wages, interest, rent, and other forms of income to people who complete this circular flow by spending the money or income they receive to buy goods and services produced by others.

Government, like all institutions, provides a service for a price. In this case, the price is taxes. Taxes paid to government represent funds that would have been otherwise used by individuals and businesses. Government through its taxing, spending, borrowing, and regulative programs changes the mix of goods and services produced.

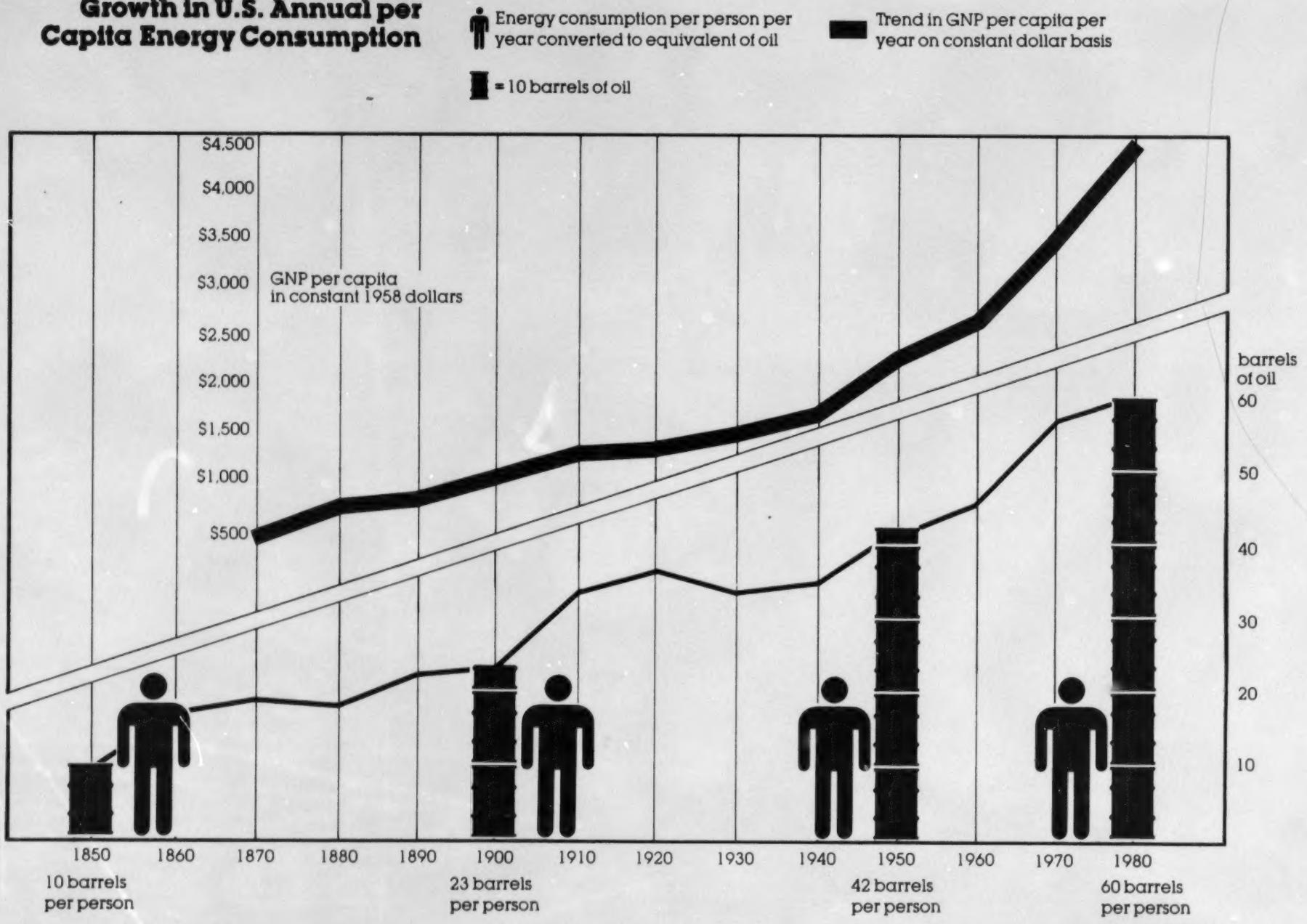
Energy Conversion

The matrix indicates typical machines, devices, and processes that convert energy from one form into another.

Conversion From:	TO CHEMICAL	TO ELECTRICAL	TO HEAT	TO LIGHT	TO MECHANICAL	TO SOUND
CHEMICAL	food, plants	battery, fuel cell	match, fire, food	candle, oil lamp, phosphorescence	rocket, gas engine, animal muscle	explosion, smoke detector
ELECTRICAL	battery, electrolysis, electroplating	diode, rectifier, transformer	toaster, heat lamp, sparkplug	television, fluorescent lamp, light emitting diode	electric motor, relay	horn, thunder, loud speaker
HEAT	gasification, vaporization, distillation	thermopile, thermocouple	heat pump, heat exchanger	fire, arc lamp, light bulb	turbine, gas & steam engines	explosion, flame tube
LIGHT	plant photo-synthesis, camera film	solar cell, photoelectric cell	laser, heat lamp	laser, light wave repeater	photo-electric door opener	light activated device
MECHANICAL	cartridge being fired	generator, alternator	friction brake	flint spark	flywheel, pendulum, water wheel	voice, musical instrument
SOUND	hearing	telephone, microphone, hearing	sound absorber	light amplifier, color organ	ultra sonic cleaner	megaphone

EXHIBIT THREE

Growth in U.S. Annual per Capita Energy Consumption



Energy Glossary

Anthracite – "Hard coal," a solid, combustible, organic hydrocarbon, low in volatile matter, high in carbon content.

Barrel (bbl) – A liquid volume measure of petroleum crude oil and refined products, equal to 42 U.S. standard gallons (159 liters) and weighing about 306 pounds.

Bioconversion – A general term describing the conversion of one form of energy into another by plants or microorganisms. It may refer to the conversion of solar energy by photosynthesis, the production of hydrogen gas by enzyme hydrogenase, or the production of alcohol or methane gas by the fermentation of organic wastes or plants.

Biomass – The total amount of plant materials, in any form from algae to wood, in a given area.

Bituminous – "Soft coal," high in volatile matter and carbon content.

Breeder Reactor – A nuclear reactor designed to produce more fissionable nuclear fuel than it consumes.

British Thermal Unit (Btu) – A standard engineering unit of heat energy. The quantity of heat required to raise the temperature of one pound of water (approximately one pint) one degree Fahrenheit.

Calorie – A metric unit of heat energy. The amount of heat required to raise the temperature of one gram of water one degree Celsius.

Catalyst – A substance which causes or changes the speed of a chemical reaction without being changed itself.

Chain Reaction – A reaction that stimulates its own repetition. In a fission chain reaction, a fissionable nucleus absorbs a neutron and splits in two, releasing additional neutrons. These in turn can be absorbed by other fissionable nuclei, releasing still more neutrons and maintaining the reaction.

Coal Gasification – A controlled chemical process in which coal, steam, and oxygen react under pressure and elevated temperature to produce manufactured gas and coke.

Coal Liquefaction – A controlled chemical process in which coal and hydrogen react to produce a liquid hydrocarbon fuel.

Crude Oil – A mixture of liquid hydrocarbons found in natural underground formations. Crude oil is the raw material from which refined petroleum products are made.

Distillation – The process which separates a liquid or solid mixture into its components by heating the mixture and then condensing the vapors given off.

Electrical Energy – Energy derived from charged particles in motion, for example, the flow of electrons in a conductor.

Energy – The capacity or ability to perform work, make changes, or make things move. Energy exists as either potential or kinetic and in many different forms, such as electrical, gravitational, nuclear, chemical, thermal, mechanical, radiant, and sound. Common units of measurement are calorie, Btu, joule, and kilowatt-hour.

Fission – The splitting of a heavy nucleus into two or more nuclei with the release of thermal and radiant energy and one or more neutrons.

Fossil Fuels – Fuels derived from the remains of carbonaceous organic fossils; include petroleum, natural gas, coal, oil shale, and tar sands.

Fuel – Anything that can be burned, oxidized, or fissioned to produce heat energy.

Fuel Cell – An electro-chemical device in which a fuel, such as hydrogen or methane, can be combined with oxygen in the presence of a catalyst to produce electricity.

Fusion – The formation of a heavier nucleus by combining two lighter ones with the attendant release of energy.

Generator – A machine that converts mechanical energy into electrical energy. Typically a coil of wire is rotated within a magnetic field. This causes electrons to flow in the wire, producing electricity.

Geologist – A scientist who studies the history of the earth and its life. Geologists are trained to recognize and analyze structural features and chemical properties of soil and rock formations.

Geophysicist – A scientist who studies the physics of the earth, including gravity, magnetism, seismology, radioactivity, oceanography, volcanology, and meteorology.

Geothermal Energy – Heat energy extracted from natural steam or hot water from the earth's interior.

Hydrocarbons – Compounds composed primarily of carbon and hydrogen atoms in various proportions.

Hydrogenation – The addition of hydrogen to an organic molecule to increase the ratio of hydrogen to carbon. An example is the production of oil or gas from coal or from organic waste.

Hydropower – Energy produced by the force of falling or moving water, used to power turbine electric generators.

In Situ – In the natural or original position or location. In situ conversion of oil shale, tar sands, or coal can take place when part of the hydrocarbon is burned underground and the resulting vaporized gases are collected and condensed.

Joule – A metric unit of work or energy.

Energy Glossary

Kilowatt-Hour – (kwh) 1,000 watt hours. A unit of electrical energy equal to the energy delivered by the flow of one kilowatt of electrical power in one hour.

Kinetic Energy – The energy of motion or the ability of an object to do work because of its motion.

Liquefied Natural Gas – (LNG) Natural gas that has been liquefied by cooling to about – 160 degrees C or – 260 degrees F. Liquefaction is expensive but storage and shipping costs are reduced since liquefaction reduces the volume to 1/600 of the gas in the vapor state.

Methane Gas (CH_4) – A colorless, odorless, flammable, gaseous hydrocarbon. Methane can be a fuel or an explosive depending on the amount of air it is mixed with. Available in the form of natural gas, marsh gas, or it can be manufactured from crude oil, coal, and other organic materials.

Natural Gas – A naturally occurring mixture of hydrocarbon gases and vapors found in underground reservoirs and existing either in a gaseous state or in solution with crude oil.

Nuclear Power – Energy derived when the nuclei of atoms are split in a controlled fission chain reaction. Heat produced during the reaction is used to boil water to create steam to power turbine electric generators.

Oil Shale – A finely grained sedimentary rock containing the solid hydrocarbon kerogen. When oil shale is crushed and heated to high temperatures, the kerogen decomposes into a gas or liquid and can be recovered for additional refining.

Petroleum – A gaseous, liquid, or solid organic fossil hydrocarbon compound usually found deep in the ground.

Photosynthesis – The process by which green plants convert radiant sunlight energy into potential chemical energy.

Photovoltaic – Related to the process by which radiant energy is converted directly into electrical energy. Solar radiation striking certain materials is absorbed, causing separation of electrons from atoms, creating an electrical potential difference or voltage.

Plutonium (Pu) – A heavy radioactive, synthetic metallic element with atomic number 94. Its most important isotope is fissionable plutonium-239, produced by neutron irradiation of the isotope of uranium-238. Plutonium can be used for reactor fuel and is created in a breeder reactor.

Potential Energy – Energy that is stored in matter because of its position or arrangement of its parts.

Power – The rate at which work is done or energy is transformed. Power is measured in units of work per unit of time.

Pyrolysis – The process of heating organic materials or wastes at high temperature, without oxygen, to extract char, gases and oil.

Refining – The separation of crude oil into its component fractions or parts, such as gasoline, kerosine, jet fuel, heating oils, etc.

Reserves – The estimated amount of a recoverable resource which analysis data demonstrate with reasonable certainty to be recoverable under existing economic and operating conditions.

Reservoir – A portion of a porous and permeable underground formation containing a natural accumulation of oil and/or natural gas, confined by rock, mineral, or water barriers.

Solar Power – Energy derived directly from the sun; electrical energy produced by the reaction of sunlight on photovoltaic solar cells, or radiant energy absorbed by solar collectors for heating purposes.

Therm – 10 cubic feet of gas. The equivalent of 100,000 Btu or 25,200 kilocalories.

Thermodynamics, First Law Of – states that energy and matter can be transformed but cannot be created or destroyed.

Thermodynamics, Second Law Of – states that in conversions of energy from one form to another, some energy passes from a useful to a less useful form.

Tidal Power – Use of the flow of water trapped from high tides to drive hydro generators for the production of electrical energy.

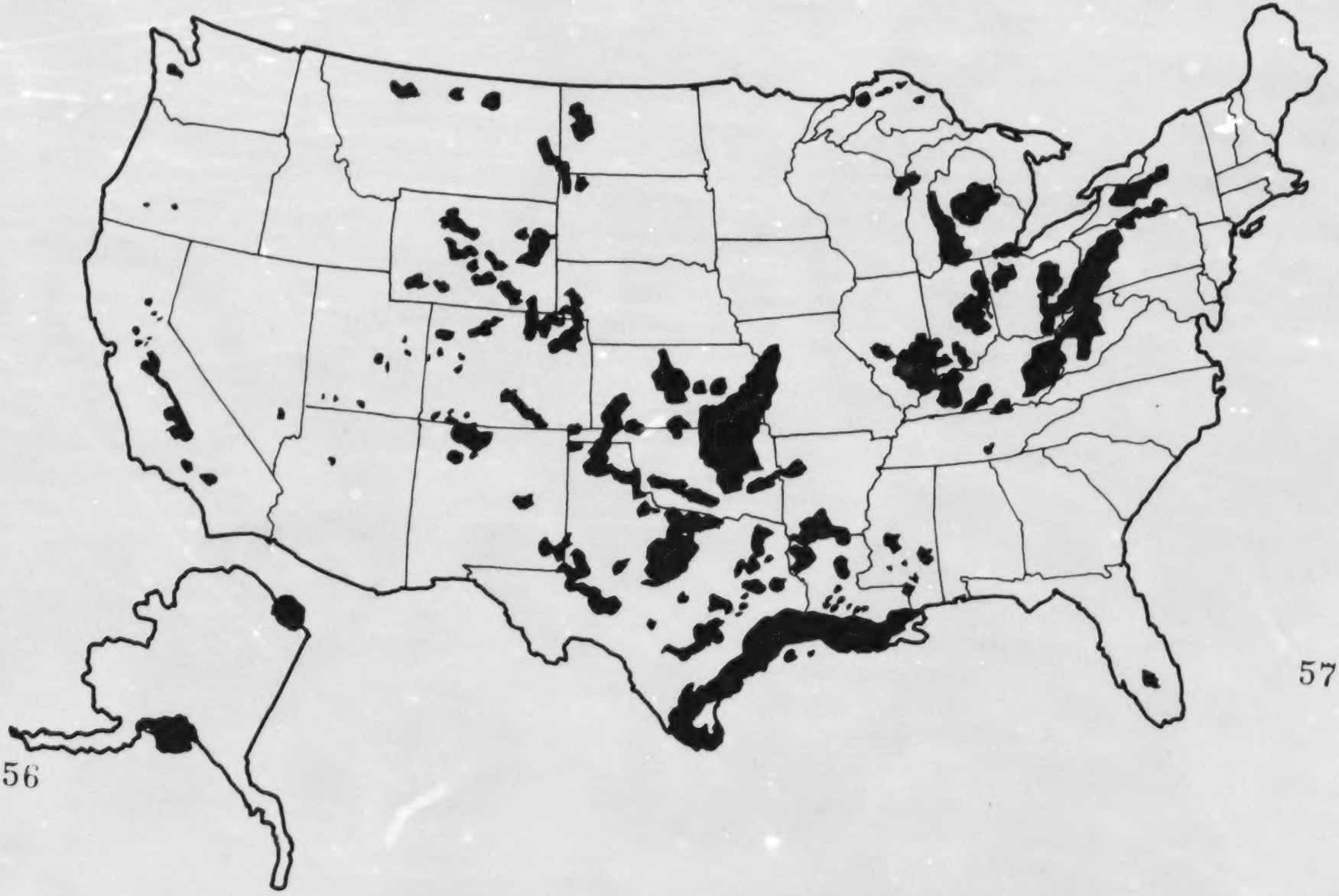
Turbine – A rotary engine that converts heat energy or kinetic energy into mechanical energy. It consists of a wheel fitted with numerous finned blades or vanes attached to a shaft. The force from jets of high-pressure steam, heated gases, running water, fluid, or wind directed on the blade surfaces rotates the turbine wheel and shaft at high speed.

Uranium (U) – A heavy radioactive metallic element with atomic number 92. It is often found in pitchblende and uraninite ores. The isotope uranium-235 when bombarded with neutrons undergoes rapid fission and is used as a fuel in nuclear reactors.

Work – The transfer of force from one body or system to another. Work is performed by a force acting against resistance moving a body over a specified distance.

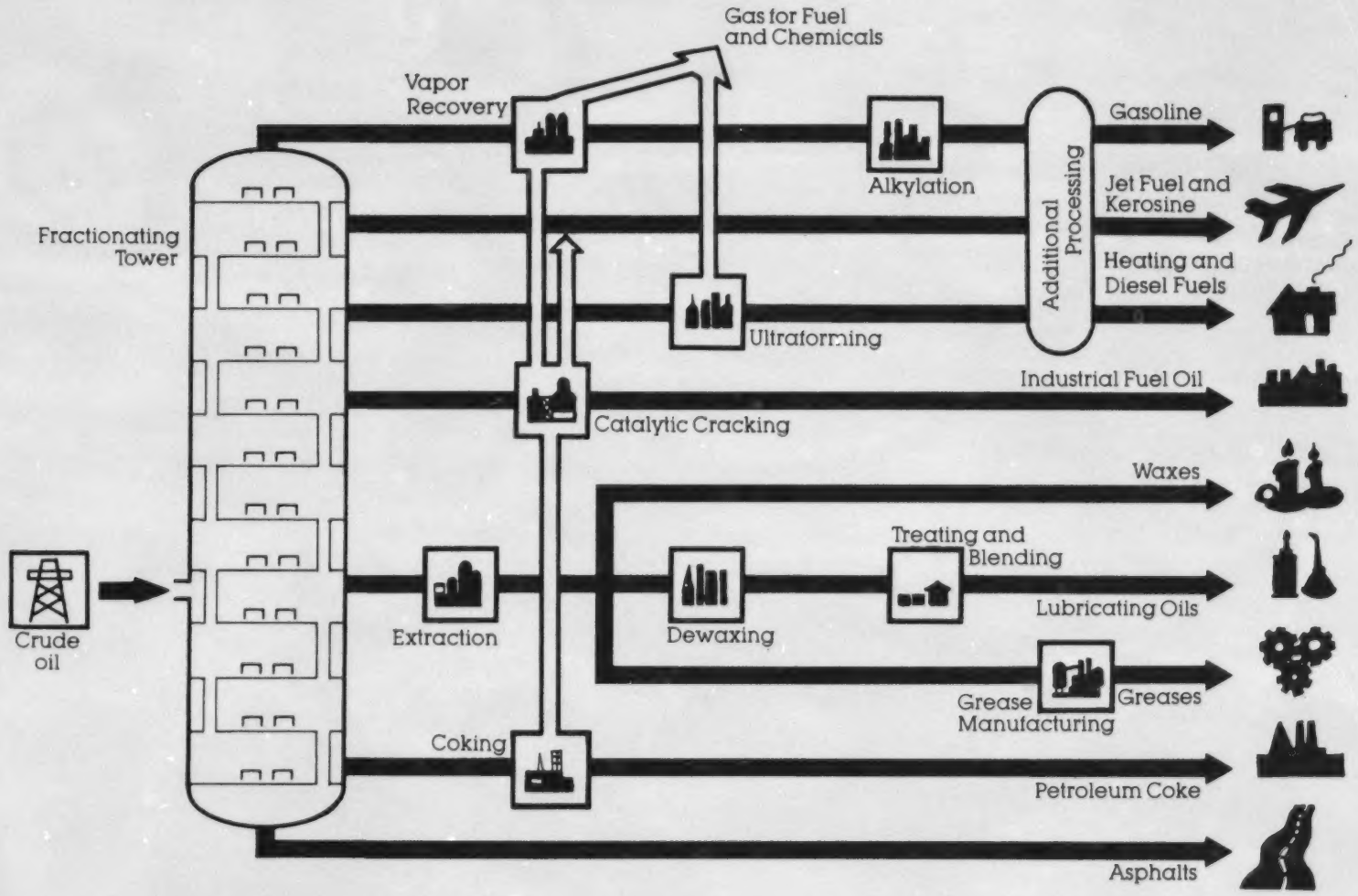
EXHIBIT FOUR

Oil and Gas Fields in the United States



Refinery Flow Chart

This is a highly simplified flow chart showing the conversion of crude oil to products useful to consumers.



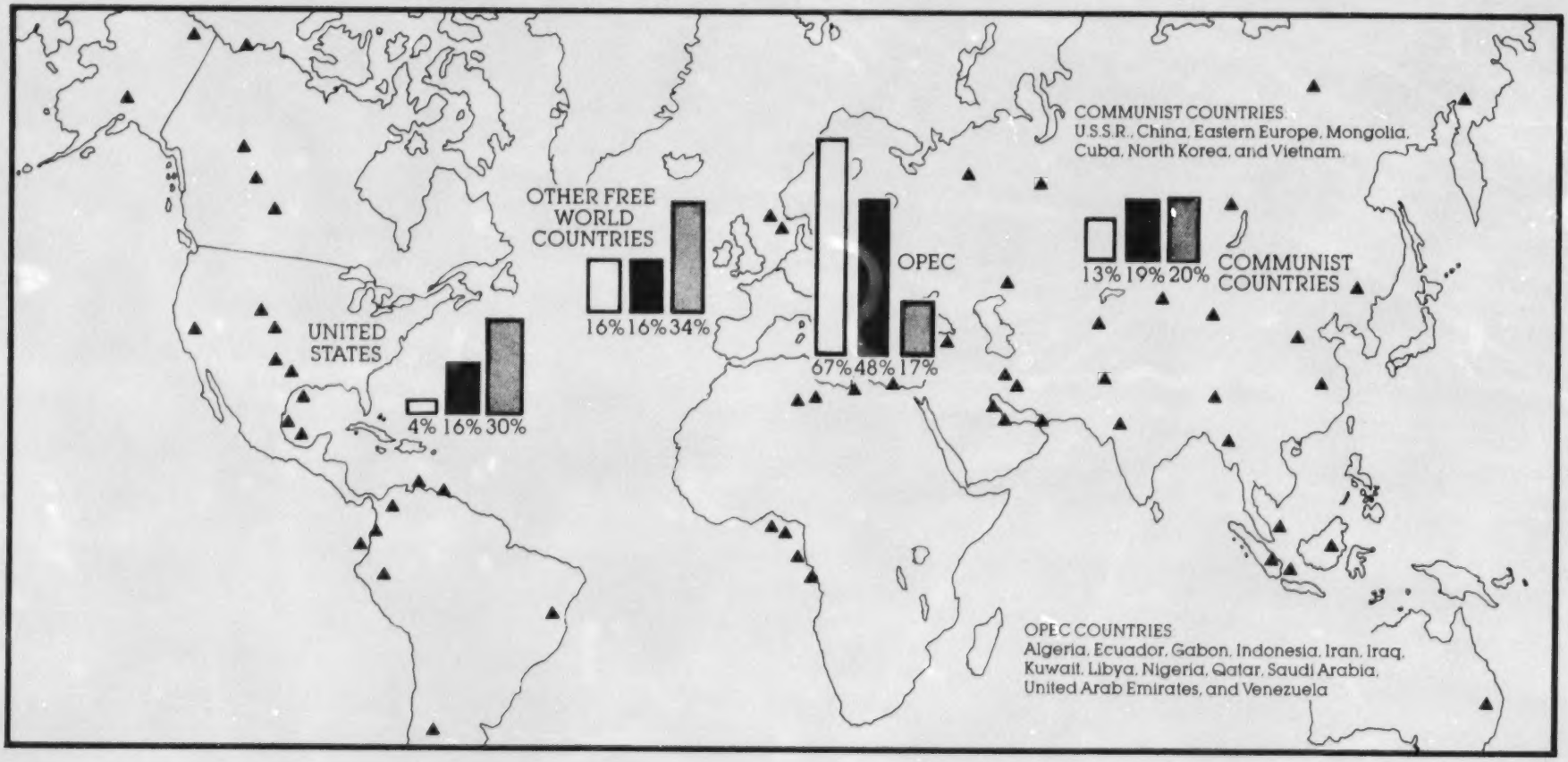
World Share of Oil Reserves, Production, and Consumption.

▲ = Major oil fields

ESTIMATED RESERVES: 649 billion barrels. OPEC 67 percent, U.S. 4 percent, Communist countries 13 percent, and other free world countries 16 percent.

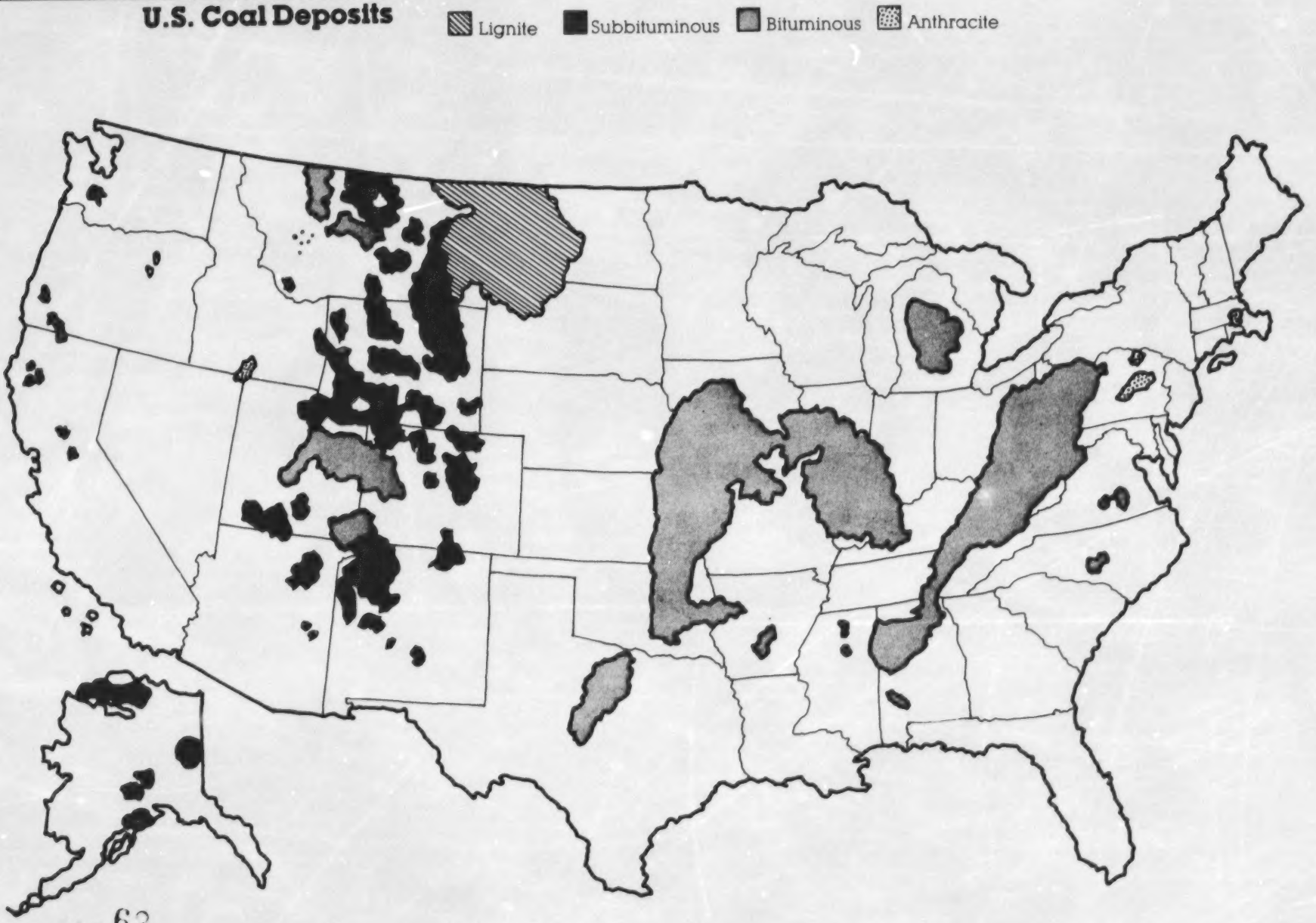
PRODUCTION: 63 million barrels per day. OPEC 48 percent, U.S. 16 percent, Communist countries 20 percent, and other free world countries 16 percent.

CONSUMPTION: 63 million barrels per day. OPEC 17 percent, U.S. 30 percent, Communist countries 19 percent, and other free world countries 34 percent.


COMMUNIST COUNTRIES
U.S.S.R., China, Eastern Europe, Mongolia, Cuba, North Korea, and Vietnam.
OTHER FREE WORLD COUNTRIES
16% 16% 34%
OPEC
67% 48% 17%
13% 19% 20%
COMMUNIST COUNTRIES
UNITED STATES
4% 16% 30%
OPEC COUNTRIES
Algeria, Ecuador, Gabon, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela

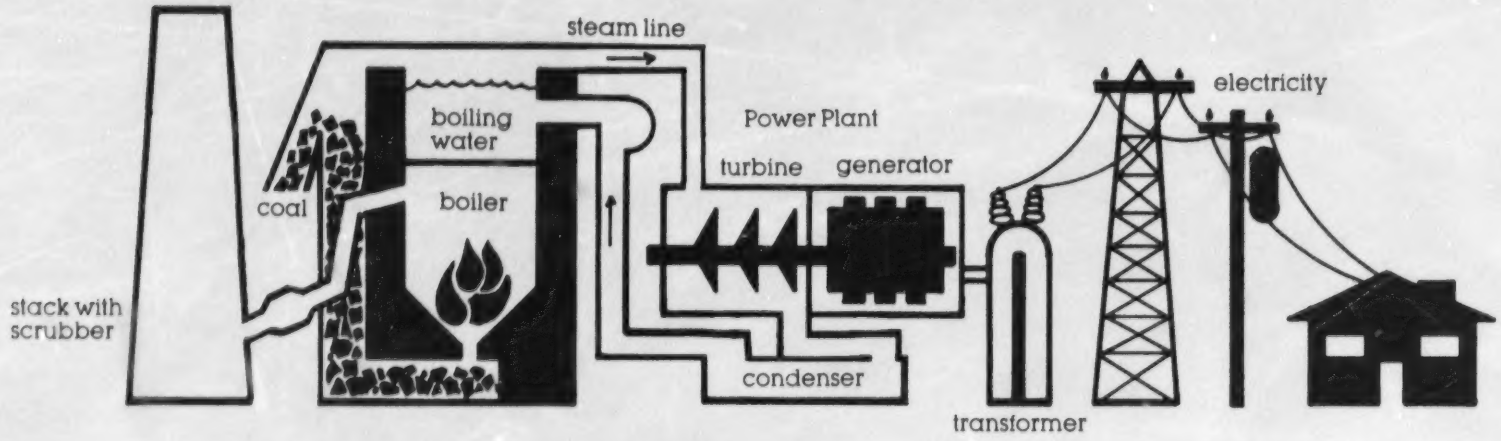
60

U.S. Coal Deposits

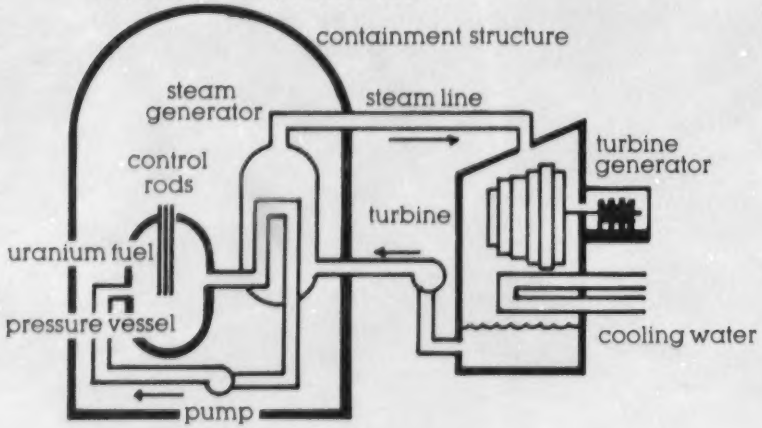


Electricity Production

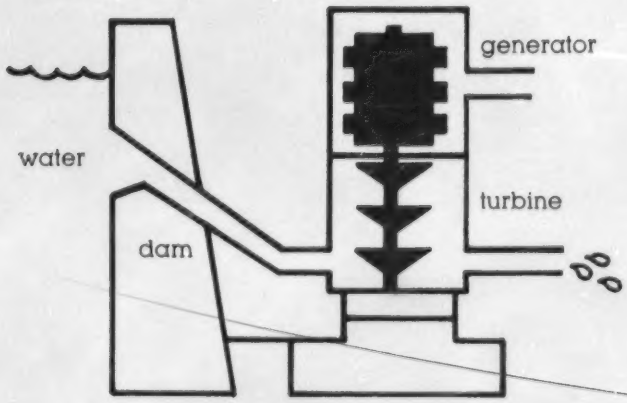
FOSSIL FUEL (COAL)
POWER PLANT



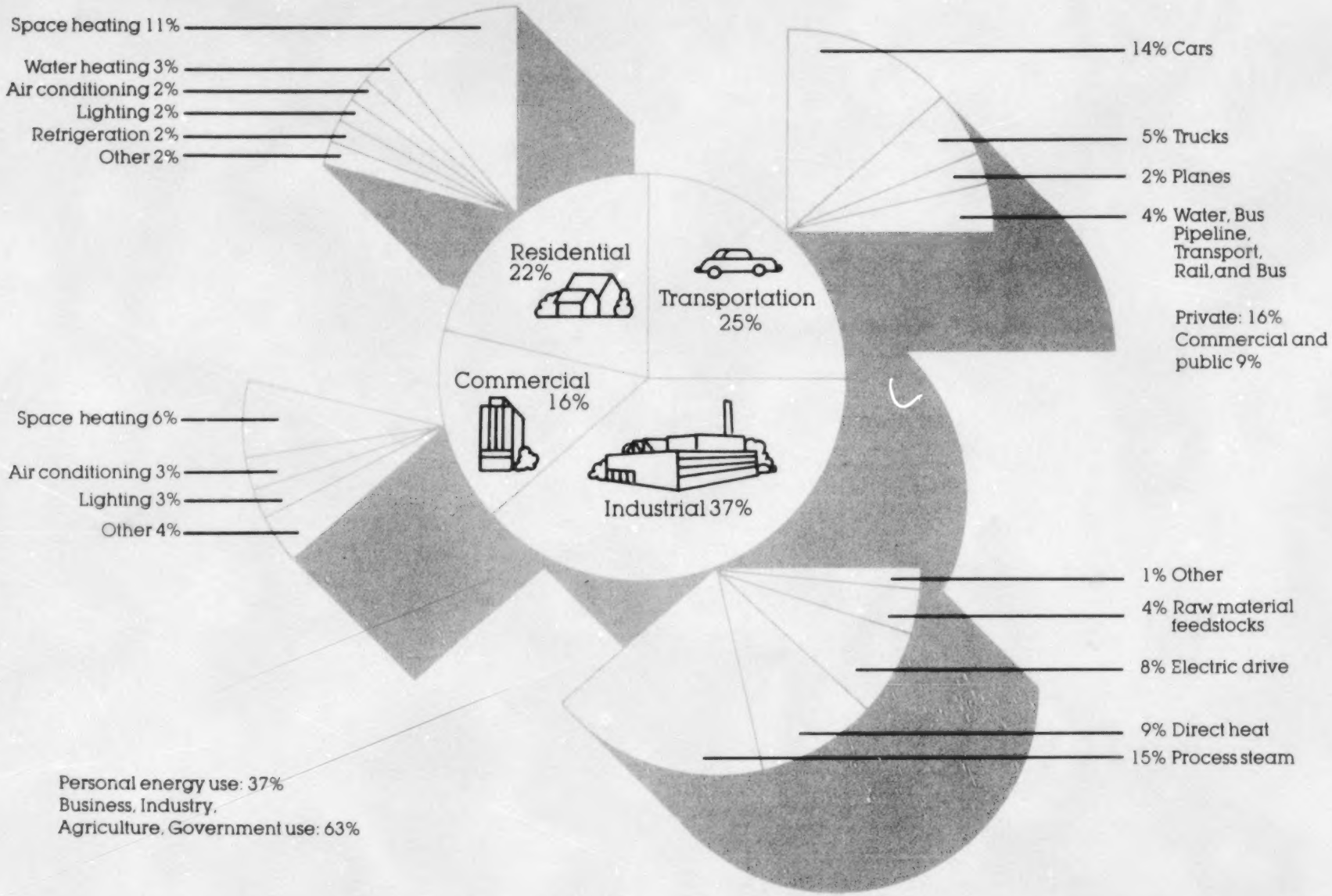
NUCLEAR POWER PLANT —
PRESSURIZED WATER REACTOR



HYDROELECTRIC
POWER PLANT



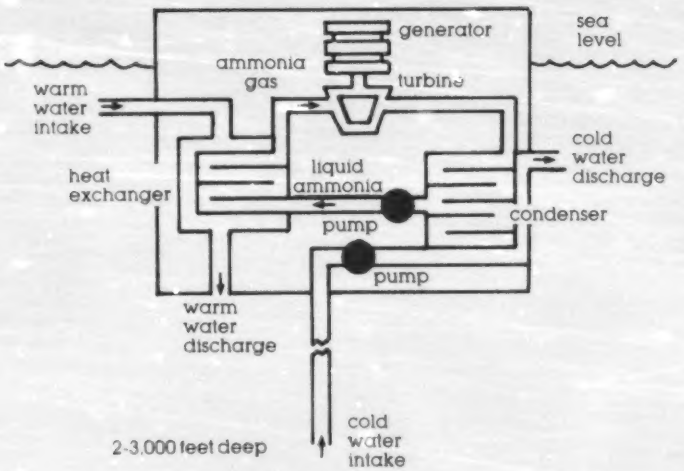
U.S Energy Usage By Economic Segment



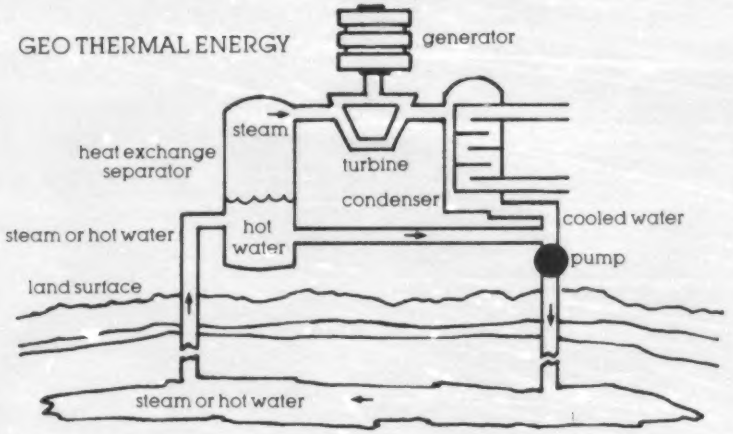
1980 U.S. Department of Energy

Optional Energy Sources for the Future

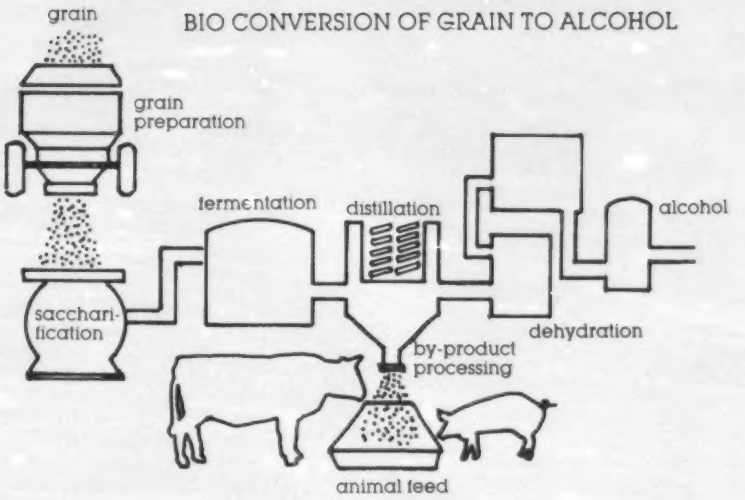
OCEAN THERMAL ENERGY CONVERSION



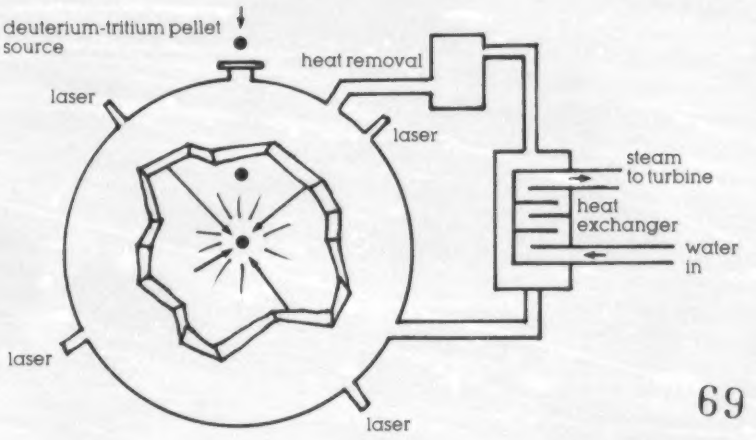
GEO THERMAL ENERGY



BIO CONVERSION OF GRAIN TO ALCOHOL

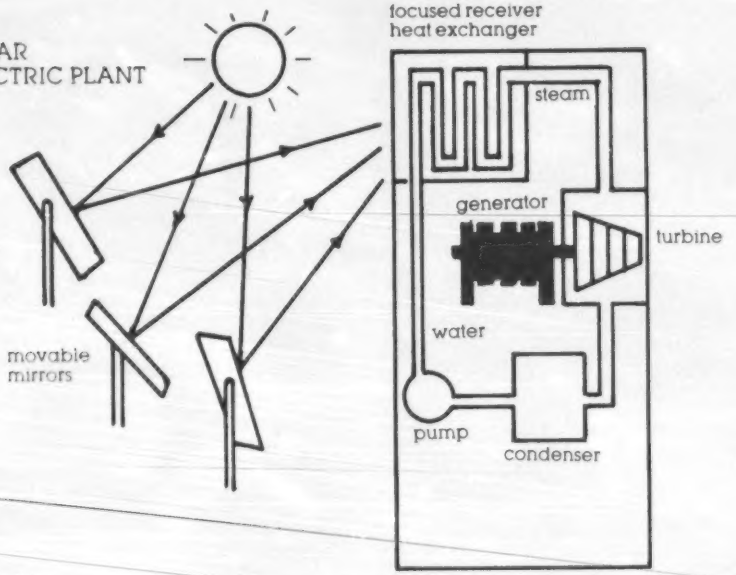


NUCLEAR FUSION

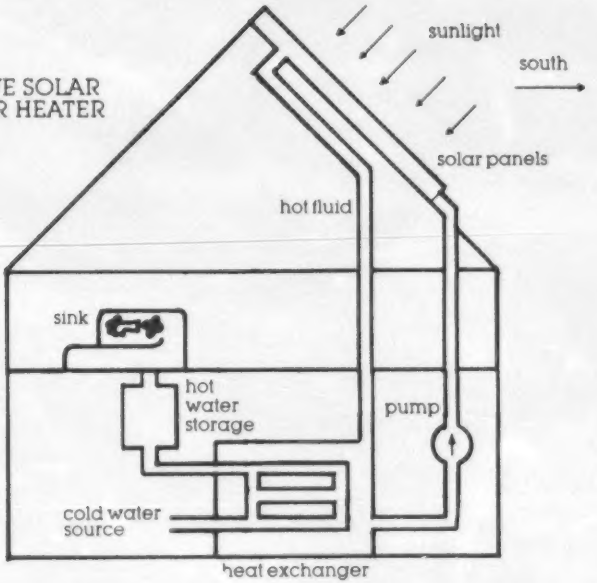


Optional Energy Sources for the Future

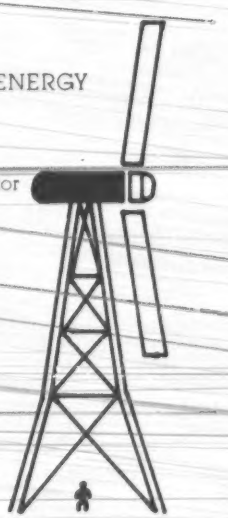
SOLAR ELECTRIC PLANT



ACTIVE SOLAR WATER HEATER



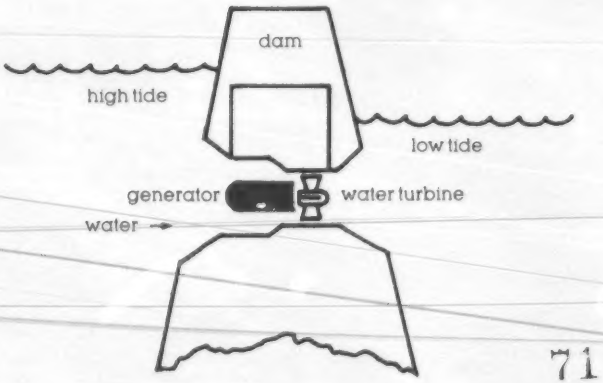
WIND ENERGY



Storage systems for excess energy

- battery
- rapidly spinning flywheel
- water pumped to higher elevation for later release
- compressed air in storage for later driving of turbine

TIDAL POWER



Regulation In response to perceived needs or to accomplish societal goals, the political system may regulate markets. Since regulation distorts the free operation of the market system, this outside influence affects supply and demand and represents an additional cost that shows up in the price of goods and services.

Government can influence the allocation of energy resources by direct and exclusive control over the production or distribution of particular types of energy. Government can also intervene in the economic decisions affecting energy supplies, prices, and the various types of energy available. Examples are utility regulation, resource allocations, environmental restrictions, tariffs, and wage laws. When government regulates an energy supply it is difficult to determine the best economic course of action.

Summary In a free market economic system consumer demand determines what is produced. Individual initiative and profit seeking businesses try to produce the goods and services consumers want at the lowest possible cost.

Each business is subject to the risks of ever-changing prices, costs, and consumer preferences. Business people develop management skills and marketing knowledge in an attempt to overcome these risks and to produce a profit for the owners or shareholders by finding better ways to satisfy customers.

Businesses also pay out wages to workers, rent to landowners, interests to lenders, and dividends to stockholders. These incomes, in turn, make it possible for these people to bid for and buy the goods and services they want. Thus, free markets, in which prices rise and fall in response to changing demands and supplies, allocate scarce resources used in the production of the most desired goods.

The prospect of profits provide a major incentive for engaging in economic activity, including investment in the future. Competition acts as a regulator of that activity. When individuals and businesses save part of their income and make these savings available for investment in new productive facilities, improved tools, or in the education and training of people, society's future capacity to produce is increased.

The private enterprise, free-market system is the most productive of all economic systems -- and the only one fully compatible with individual liberty. It has demonstrated its superiority over all other systems of economic organization in the efficient allocation of limited resources to satisfy unlimited human demand.

Individual freedom of choice and personal responsibility -- within a framework of legal, social, and moral pressures designed to protect the individual and society -- are the principles that guide the private enterprise market-directed American economy.

ADDITIONAL ACTIVITIES

1. After discussing this activity, students can be assigned to explore one economic concept in greater depth and write a paper or make a report to the class.

2. You may wish to have the class debate whether competition exists in the energy industry, if energy prices should be set by the free-market, or it they should be controlled by government.

3. Ask an energy company representative to visit your class and discuss trends in energy costs, capital formation, competition, profits, regulations, and consumer relations.

Answers to Energy and Economics Quiz: 1-a, 2-a, 3-c, 4-b, 5-c, 6-b, 7-a, 8-b, 9-c, 10-b, 11-a, 12-c, 13-b, 14-a.

We acknowledge the generous help of Dr. Marianne Talafuse, Associate Director, Center for Economic Education, Ball State University, who reviewed and provided editorial assistance for this section on Energy and Economics.

Energy and Economics Quiz

Circle the correct answer.

1. Economic wants are:
   a unlimited
   b relatively limited
   c limited

2. What do productive resources include?
   a workers, natural resources, and capital
   b food, shelter, and clothing
   c education, work, and power

3. Which is most likely to improve productivity?
   a risk taking
   b a high standard of living
   c capital investment

4. What is the most basic economic problem?
   a opportunity costs
   b relative scarcity
   c interdependence

5. What opportunity costs are involved in producing energy?
   a increasing costs of producing energy
   b costs of conserving energy
   c resources used in producing energy cannot be used to satisfy other human demands

6. How would you define an energy market?
   a any place where energy is transported
   b any situation where buyers and sellers engage in mutually beneficial exchange
   c any amount of energy produced for sale

7. What is an energy supply?
   a the amount of energy producers are willing and able to provide at specific prices
   b the ability to explore for energy
   c the need to produce energy at a low price

8. What will happen to the price of energy if petroleum demand continues to grow?
   a energy prices will not change
   b energy prices increase or decrease depending on supply
   c energy prices will decrease

9. What does economic demand for an energy product refer to?
   a the amount of product people want
   b the amount of product available for sale
   c the amount of product people are willing and able to buy at specific prices

10. How would you define the price of any energy product?
    a the changing prices of production
    b the amount of money the buyer and seller exchange for an energy product
    c the amount of money a company pays to make an energy product

11. What do free market prices reflect?
    a the scarcity of a product
    b the need to make a profit
    c the need for government control to keep prices low

12. How does competition affect the economy?
    a reduces prices and reduces the amount of goods available
    b increases profits but does not reduce prices
    c reduces prices, allows innovation, and provides more goods and services

13. In what way do profits act as economic incentives?
    a they are used to produce more goods
    b they are the reward for taking a business risk
    c they provide funds to pay workers better wages

14. How does the division of labor improve efficiency?
    a allows people to produce more goods and services
    b keeps mathematicians employed
    c makes it difficult to find skilled labor

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Arthur C. Bailey, Jr., Operations Supervisor
Energy Education Division
Oak Ridge Associated Universities

Carl Fischer, Director, Creative Services
The Communications & Education Group

Robert Grierson, Teacher
Alter High School, Kettering, Ohio

Martin J. Shallenberger, Chairman
National Association for Industry-Education Cooperation

George Smolinski, Teacher
Fairmont West High School, Kettering, Ohio

Gene E. Willeke, Director
Institute of Environmental Sciences

Donald Weimert, Teacher
Chaminade-Julienne High School, Dayton, Ohio

John A. Zaidain, Teacher
Chaminade-Julienne High School, Dayton, Ohio

Individual sections of Energy Adventure were reviewed by:

Activity 2 Petroleum —Janet S. Dove, Staff Advisor-Education
Cynthia Riggs, Geologist
American Petroleum Institute

Activity 3 Natural Gas —Isabelle T. Laučka, Manager-Educational Programs
American Gas Association

Activity 4 Coal —Betsy Kraft, Director-Educational & Training Services
National Coal Association

Activity 5 Electricity —Walter L. Purdy, Manager-Educational Services
Edison Electric Institute

Activity 7 Conservation —Ellen Morgenstern, Director Communications
Alliance to Save Energy

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Additional Sources of Energy Information

Contact your local electric or gas utility, coal dealer, or oil company for additional information, films, and other educational resource materials.

You can also write directly to the following organizations:

American Gas Association
1515 Wilson Boulevard
Arlington, VA 22209

American Petroleum Institute
2101 L Street, N.W.
Washington, DC 20037

Edison Electric Institute
1111 19th Street, N.W.
Washington, DC 20036

National Coal Association
1130 17th Street, N.W.
Washington, DC 20036

U.S. Department of Energy
Technical Information Center
P.O. Box 62
Oak Ridge, TN 37803

Consumer Information Center
Pueblo, CO 81009